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THE REMAINS OF WILLIAM HARVEY.

By BENJ. W. RICHARDSON, M.D., F.R.S.

MY late beloved and honored friend, Dr. Robert Willis, of Barnes, in his life of Harvey, describes, after Aubrey, the death and burial of our greatest English anatomist. On the third day of June, 1657, about ten in the morning, Harvey, then in his eightieth year, on attempting to speak, found that he had lost the power of utterance—that, in the language of the vulgar, he had the dead palsy in his tongue. He did not lose his other faculties, however ; but, knowing that his end was approaching, he sent for his nephews, to each of whom he gave some token of remembrance—his watch to one, his signet ring to another, and so on. He further made signs to Sambroke, his apothecary, to bleed him under the tongue; but this did little or no good, and by and by, in the evening of the day in which he was smitten, he died, the palsy giving him an easy passport. The funeral took place a few days afterward, the body being attended far beyond the walls of the city by a long train of his friends of the College of Physicians, and the remains were finally

Fig. 1.—PROFILE OF BUST—WILLIAM HARVEY.

deposited in a vault at Hempstead, in Essex, which his brother Eliab had built. He was lapt in lead, and on his breast, in great letters, his name, "Dr. William Harvey." "I was at his funeral," continues Aubrey, "and helped to carry him into the vault." This is the brief account of the placing of the remains in the vault of the church at Hempstead, and there they still remain, probably in precisely the same position as they were left by Aubrey and his colleagues two hundred and twenty-one years ago.

Hempstead is a village about seven miles from Saffron Walden, and the best way for those who wish to pay a pilgrimage to it is for them to take the train to Saffron Walden, and from thence by carriage on to Hempstead. They will find no obstacle in the way of seeing the vault and the remains; on the contrary, they will have a willing and intelligent guide in the sexton, Mrs. Ford, who lives close by, who has the keys of the church and vault, and who will give much very useful and correct information respecting the Harvey Chapel, the vault, and the various members of the Harvey family, many of whom, as well as the anatomist, are buried at Hempstead.

In my early life I lived for nearly two years in Saffron Walden, assisting the late Mr. Thomas Brown, surgeon of that place. Some time about Christmas, 1847, I was attending, in her accouchement, the wife of a cottager at a village called Radwinter, near to Hempstead; and, while waiting in the night, I heard from the husband of my patient an interesting story of the chapel and vault of the "great Dr. Harvey." Gradually it dawned on me that the Harvey re-

Fig. 2.—HARVEY MEMORIAL TABLET AND BUST.

ferred to must be the discoverer of the circulation of the blood. On further inquiry I found this to be the fact. Very soon, as may be expected, I visited the church; and a year or two later, when I became acquainted with Dr. Willis, whom for a time I joined in practice at Mortlake, I reported to him the condition of the remains for a proposed new edition of a life of Harvey, which he had at that time in contemplation, apart from the edition of the Sydenham Society, which he had already prepared and brought out.

As far as I could learn in 1847, the vault containing the remains of Harvey had not then been visited by men of science within the memory of any person in the village of Hempstead, neither had any one been curious about it. The villagers said they knew Dr. Harvey was a very great man, who had, they had heard, made some great discovery, but they did not know what it was. They held the whole of the Harvey family, however, in much reverence as an old county family of high distinction, with merchants and knights, and even baronets, connected with it. At that time the vault had been long and grievously neglected. The vault was practically open to the public, for the window in it at the eastern end was uncased and badly barred, and the leaden shell in which Harvey lies on the floor was exposed to drift of rain whenever the rain beat in from the east, and was, in fact, altogether unprotected. Boys could throw stones upon the leaden sarcophagus, and did so. Indeed, it is not too much to say that any unscrupulous antiquarian, corrupted to theft by the desire of possession of a great relic, might with the utmost ease have purloined the remains of Harvey,

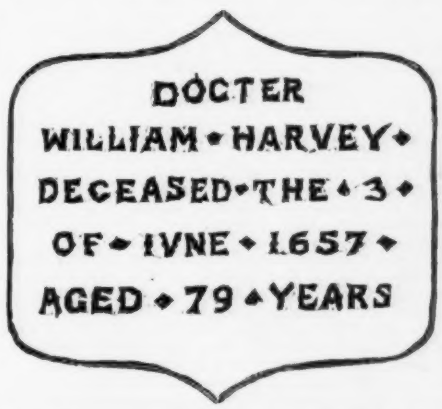


Fig. 3.—INSCRIPTION ON BREAST-PLATE OF SARCOPHAGUS, FROM A RUBBING OF THE PLATE.

without much fear of detection. At that time there was a small rent almost through the lead, on the upper surface of the shell, in the upper third of its length from the feet. The leaden case was also beginning to bend in over the middle of the body, looking like a large scoop or spoon, in which water could accumulate ; but whether at that time water had permeated into the shell I cannot say. I think it had not.

In 1859, a visit to the remains was made by Drs. Stewart and Quain, at the request of the Royal College of Physicians. Their report was very exact and accurate. At the time of their visit the case was probably full of dirty water, which had, I have no doubt, got into it through the crack or opening to which I have referred, which had become enlarged, and which had penetrated quite through the lead.

Some repairs were made in the vault after the visit and report of Drs. Stewart and Quain, and in 1868, when I made another of my pilgrimages to Hempstead, the vault looked comparatively fresh, clean and dry. The window had been barred; either a new entrance had been made into the vault or the old one had been very much improved; many of the other coffins and leaden cases in it, containing the remains

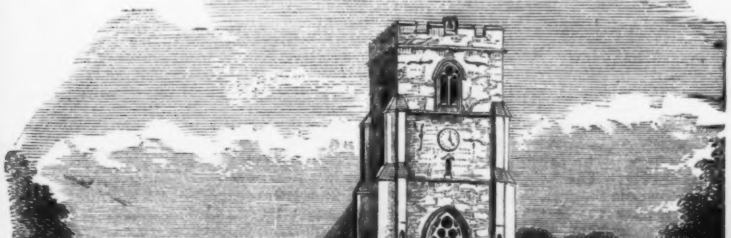


Fig. 4.—HARVEY'S BURIAL PLACE—HEMPSTEAD CHURCH FROM THE WESTERN SIDE.

Eig. 5.—HARVEY'S BURIAL PLACE—HEMPSTEAD CHURCH FROM THE EASTERN SIDE.

THE REMAINS OF WILLIAM HARVEY.

of the members of the Harvey family, had been neatly arranged, and the sarcophagus containing Harvey was both dry and clean. By this time, however, the opening in the sarcophagus had become so large that two or three fingers could easily be introduced into it. Mr. A. Haviland, Dr. L. Sedgwick, Mr. Stear of Saffron Walden, the late Dr. Forbes Winslow, and some other friends, were with me on this occasion, and while I was examining the opening in the case or shell, Winslow holding a lamp I had brought with me, a frog leaped out of the opening. I tried to throw a light, by reflection, through this opening into the case, in order to determine if any part of the body was still in the case, but was unable to arrive at a satisfactory conclusion on the point. There was no water in the case then. At this visit in 1868 I paid more attention than I had previously done to the Harvey Chapel within the church. In the wall of the church is a memorial tablet or monument of Harvey himself. In the recess of the monument is a marble bust of Harvey, and on examining the bust I was first led to the conclusion that the sculptor had copied from a cast of the face taken after death.

On July 19th of the present year, in company with my friend Mr. Thomas Woolner, R.A., and my son Bertram, I paid another visit to Hempstead, having with me Mr. F. T. Day, of Saffron Walden, to take photographic views of all that might be of interest and importance in connection with Harvey. The skill with which Mr. Day has fulfilled his task deserves the highest commendation. He has produced a series of the most beautiful photographs, from five of which Mr. George Evans, with great fidelity and artistic taste, has produced the drawings which accompany this narrative.

In describing from this last visit, I am led naturally from one subject to another by the views themselves. The church, as will be seen from the fourth sketch, which represents the western end, stands out quite alone, and is on rising ground. It is, I believe, a church of the reign of Henry the Seventh, though some parts are said to be much older. The Harvey Chapel dates from the time of William Harvey, the vault having been built by his brother Eliab. Within the church is what is called the Harvey Chapel. This is situated at the northeast corner of the church, to the left of the altar as you stand before it. The chapel is a handsome little ruin over the vault, and it contains several monuments of the family. It has a window looking to the north, to the left of which are two monuments—one to Admiral Sir Eliab Harvey, who was born on the 5th December, 1758, and died on the 20th February, 1830, and another to Lady Louisa, the wife of the Admiral, who died on the 4th December, 1841, at the age of eighty-four. The Admiral was the last descendant bearing the name of Harvey. He was the third son of William and Emma Harvey. He died at Roll's Court. The Admiral had three sons, all of whom died in his lifetime, and two of whom lie in the vault with him at Hempstead. He left six daughters—namely, Mrs. Lloyd, Mrs. Drummond, Mrs. Bramston, Mrs. Towers, Lady Eustace, and Mrs. Fane.

On the right hand side of the window of the chapel are three monuments. One, nearest the window—a large tablet—contains the account of Harvey's brother Eliab, the merchant, of the two daughters of Eliab (Sarah and Elizabeth), of his wife (Mary), of his eldest son, Sir Eliab Harvey, Knight, who died February 20th, 1698, aged 64; of Matthew, the son of Sir Eliab, who died in 1692, aged 23 years, and of some other members of the family. The next monument from the window on the right records the death of William Harvey of Roehampton, who died on August 13th, 1719, at the age of 80; and of his wife. On the third monument is recorded the death of William Harvey of Chigwell, and of his wife, parents of the Admiral above named.

THE BUST OF HARVEY.

Turning round from the chapel into the aisle of the church, and looking westward, there is, on the right hand, in the wall of the church, and raised so high that the upper part of it is in a line with the spring of the roof of the aisle, a marble tablet or monument containing the bust of William Harvey (Fig. 2). The ornamentation of the tablet is bold and effective, and below the bust is the following inscription, which is here literally rendered from a photographic copy:

GVLIELMVS HARVEIVS
Cui tam colendo Nomini assurgunt omnes Academiæ
Qui diurnum Sanguinis motum Post tot Annorum
Millia Primus inuenit
Orbi Salutem Sibi immortalitatem
Consequutus.
Qui ortum et generationem Animalium Solus omnium
A Pseudophilosophia Liberauit.
Cui debet
Quod sibi innotuit humanum genus Seipsam medicina
Sereniss: *Maiestat: JACOBO* et *CAROLO* Britanniarum
Monarchis
Archiatrus. et charissimus
Colleg: Med: Lond: Anatomes et Chirurgiæ Professor
Assiduus. et Fœlicissimus.
Quibus Illustrem Construxit Bibliothecam
Suoq Dotauit et Ditauit Patrimonio.
Tandem
Post triumphales
Contemplando. Sanando. inueniendo.
Sudores.
Varias domi forisq Statuas Quum totum circuit
Miccrocosmum Medicinæ Doctor ac Medicorum
Improles Obdormiuit.
III°. IVNII. Anno. Salutis CIↃ IↃCLVII. Ætatis LXXX°.
Annorum et Famæ Satur.

There have been many portraits of the great anatomist, but, for reasons I am about to give, the bust which stands above this inscription is, I think, the most interesting of all. In studying the bust in 1869, I came, as I have said, to the conclusion that it must have been copied from a cast of the face of Harvey, taken after his death. I was, however, unwilling to trust my own judgment on this point, and therefore it was that I asked Mr. Woolner to accompany me on the last occasion of my visit, and to give his opinion on the subject. Mr. Woolner was good enough to comply with this request, and, after a very careful examination, he too has come to the decisive conclusion that the bust was from an after-death cast. Every part of the evidence, Mr. Woolner tells me, points to this decision. The features are those of a face dead. The sculptor, whoever he might be, has exhibited no knowledge of sculpture, except when he was copying what was directly before him. With the cast of the face for his copy, he has shown true artistic delineation, but all that he has been obliged to add to make up the bust as it stands is of the worst possible quality. The ears are placed entirely out of position; the large redundant head of hair is altogether out of character, imaginary, and badly executed, and the drapery of the shoulders is simply despicable. We have, nevertheless, to thank the rude sculptor for the care he has devoted to the face, and we are enriched by the knowledge, supplied to us by the greatest of living English sculptors in our day, that the true lineaments of William Harvey, as they were seen at the time of his death, are in our possession. These lineaments indicate a face at once refined, reflective, and commanding, a far nobler portrait of the man, as I think, than any that has passed to us from the hand of the painter. In order to get the features, as shown in the bust, into the sharpest possible outline, I instructed Mr. Day to raise his camera so as to take a photograph in profile, in such position as Mr. Woolner felt would give the most perfect view. The result left nothing to be desired, and in the first drawing the profile is reproduced with singular fidelity. If the reader will turn the page round so as to make the face look upwards he will see William Harvey as Aubrey, Sir Charles Scarborough, and other friends saw him before the solderers closed his body in the shell which still remains.

THE VAULT AND SARCOPHAGUS.

In the fifth engraving the reader will find the eastern view of the church at Hempstead; and if he will look at the lower building on the right-hand side, he will see a double arched window and a door, with a tombstone between them. Immediately behind that tombstone is the window in the wall of the vault beneath which the foot of the sarcophagus containing Harvey lies. To enter the vault we have to go a few steps along the side of the building which looks to the north, and in which there are two windows. In the ground beneath the first of those windows is the entrance that leads down to the vault. Two folding trap-doors give the admission down a flight of brick steps. When we reach the bottom of the steps, we find ourselves in a rather large room, with brick floor and almost flat ceiling, with another vault beyond, the door of which is nearly opposite. To the left, as we stand at the foot of the steps looking northward, is the little east window of which I have spoken, and beneath which, with his feet towards it, lies Harvey. By his side, in leaden shells like to his own, lie several other members of the Harvey family; and in the extreme left-hand corner are coffins one above another. All the leaden shells or cases have on them inscriptions, that immediately next to Harvey being rather long, but still very legible; it describes one Matthew Harvey, who was at the battle of the Boyne with William of Orange.

To obtain a picture of the sarcophagus containing Harvey himself I lighted up the vault with the magnesium light, and thus enabled Mr. Day to take with this light, and with the light of the sun from the window, the photograph from

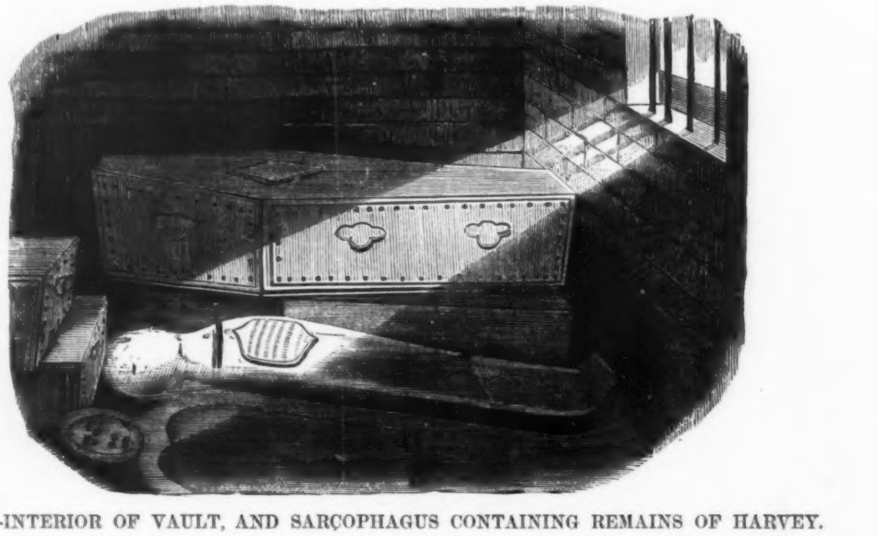


Fig. 6.—INTERIOR OF VAULT, AND SARCOPHAGUS CONTAINING REMAINS OF HARVEY.

which the engraving (Fig. 6) has been drawn by Mr. Evans. The precise position and form of the sarcophagus is thus brought to view. It is the sarcophagus on which the light is falling from the window, and on which the breastplate is indicated.

The sarcophagus containing what there still may be of Harvey lies direct on the floor of the vault, and has never, I believe, been raised on any support. The attendant at the vault declares that it has never been moved from the position in which it is now placed. Speaking from first recollections, I believe that in 1847 no other cases were near it; but I made no measurements until this last visit, and no correct notes, so I cannot speak positively; and, as at Drs. Stewart and Quain's visit, it lay in the center of a row of twelve other similar shells, my memory may be at fault.

The leaden case or sarcophagus is roughly shaped out in the form of the body. The head part has the rude outline of a face, with mouth, nose, and eyes; and the neck is wide and the shoulders expanded. The breastplate is broad, and the inscription upon it is in raised letters. The third engraving gives the inscription from a rubbing. The body of the sarcophagus is long, and tapering towards the feet. At the feet the lead turns up as if to receive the feet at a right angle to the body. In the middle of the shell, extending from the middle of the trunk to the feet, the upper surface has now collapsed, so that the inner upper surface of the lead all but touches the lower inner surface. This collapse of the lead is very much greater than it was ten years ago.

The following are the measurements of the sarcophagus, taken by my son, Bertram Richardson, on July 19th, 1878:

	Ft.	Ins.
Extreme length from crown of head to toe..	6	3
Breadth across shoulder....	1	9
" " pelvis........................	1	4
" " feet		7
Depth, measuring from the surface line above to the floor of the vault—at shoulder ...		10
Ditto, at pelvis........................		6
" at ankle........................		5
" at foot, heel to toe......		8
Breastplate....	12 inches by	8

These dimensions were taken with the idea that they might have afforded evidence of the stature of Harvey during life. They evidently do not give the least evidence on this point. Harvey was a man of small size, and the case in which he was buried was obviously made of much greater dimension than was required.

In the upper surface of the leaden case, at the point where the depression is most determinate, is the large crack, or opening, to which reference has already been made. This crack is fully six inches long. Owing to the greater collapse and the sinking in of the lead, the fissure is not so wide as it was in 1868; indeed, the edges are now closed to a space of half an inch at the widest part.

The question which interests us most has yet to be considered: Are any remains of Harvey left in the sarcophagus? Expecting to find the opening in the lead in the same condition at my latest visit as it was at the latest but one, I took with me a small mirror, a magnesium light, and every appliance for making what may be called a sarcophoscopic investigation. To my dismay, I discovered that the opening is now almost closed by the collapse of the lead, so that the reflector could not be used; while the shell is positively filled, at the opening, with thick, dirty fluid, like mud—a fluid thick as melted pitch, and having a peculiar organic odor. This extends into the case above and below the crack or fissure. There can be little remaining of the body; not much, probably, even of the skeleton.

In this brief recital I have, I trust, carried the readers of the *Lancet* with me to the last that is mortally left of William Harvey. One duty more lies before me—namely, once again to urge that these honored remains, though they are now better preserved than they have been in some times past, and though little of them may exist, should be conveyed to their one fit and final resting-place—Westminster Abbey. There, laid two feet deep in the floor, in some quiet corner, and covered merely with a thick glass plate, the leaden sarcophagus, still visible to those who take an interest in one of the most remarkable men in the history of science, would be protected for ages, instead of being destined, as it now certainly is, to fall into a mere crumbling, unrecognizable mass, in the course, at furthest, of another hundred years.—*London Lancet.*

MILK AS A VEHICLE OF CONTAGION.

By Alexander R. Becker, M. D., Berkeley, California.

Among the many questions now agitating the scientific world there is, perhaps, no one of more vital importance than the germ theory of disease; and, up to the present time, at least, the most important application of this theory has been to the so-called zymotic diseases. These diseases are also attracting close attention on account of the fearful ravages caused by them, every year, in our cities, as well as in the rural districts. Any light which can be thrown on their origin and spread must, therefore, be hailed with satisfaction.

There is one source which, we think, has not been sufficiently insisted upon, although it has attracted more attention in England than in this country; and that is *milk.* How many householders ever think of inquiring where their milk supply comes from, or what are the sanitary conditions of the farm or dairy whence it comes? In several of the States there are "milk laws;" and some of our large cities have "milk inspectors," who examine the milk, more or less carefully, for "adulterations." But no care of chemical or microscopical analysis can discover the infinitely more dangerous disease germs or contagia. If the disease germs be present in the water which supplies the dairy they will surely get into the milk, either innocently, through the necessary washing of the cans, or wrongfully, through intentional "watering." Or, if they should be present in the atmosphere, they would naturally be attracted and absorbed by a fluid so rich in nitrogen and water; which would also afford them a pleasant resting place until, by its consumption, they could reach an appropriate nidus.

In England, several epidemics have been directly traced to the milk which came from dairies where the water supply was found to be contaminated. In one case—at Bolton—forty-seven out of fifty families supplied from the same dairy were smitten with typhoid fever. On examination, the water supply of this dairy was found to have been polluted by the dejections of a typhoid fever patient.*

When we remember the utter carelessness which prevails in the country generally, on the subject of drains and privies, and their position relative to brooks and wells, we must stand appalled at the resultant danger. And here we find a very probable origin of many of our city epidemics. Moreover, we see that, in order to make our milk laws and milk inspection effective, they must be extended so as to cover *all* milk farms, with their dairy buildings, system of

* See paper by Dr. John Dougall, Medical Officer of Health for the Burgh of Kinning Park, Glasgow; *Glasgow Medical Journal*, May, 1873, p. 312. Also, "Eighth Annual Report of the State Board of Health of Massachusetts," 1877, p. 122.

sewerage, and water supply. This would of course be very unpopular with the farmers, and would entail considerable expense, as it would largely augment the labors of the State Boards of Health.

But, if the people could be brought to see (1) the enormous death-rate from the contagious fevers; (2), the great danger of drinking milk containing contagia; and (3), the strong probability of such contamination of their milk supply, owing to the ignorance and carelessness of dairymen, public opinion would soon demand the passage and strict enforcement of such preventive measures.—*N. Y. Medical Journal.*

LAUGHTER AS A MEDICINE.

THERE is not the remotest corner or little inlet of the minute blood vessels of the human body that does not feel some wavelet from the convulsion occasioned by good hearty laughter. The life principle, or the central man, is shaken to the innermost depths, sending new tides of life and strength to the surface, thus materially tending to insure good health to the persons who indulge therein. The blood moves more rapidly, and conveys a different impression to all the organs of the body, as it visits them on that particular mystic journey when the man is laughing, from what it does at other times. For this reason every good, hearty laugh in which a person indulges lengthens his life, conveying, as it does, new and distinct stimulus to the vital forces. Doubtless the time will come when physicians, conceding more importance than they now do to the influence of the mind upon the vital forces of the body, will make up their prescriptions more with reference to the mind and less to drugs for them; and will, in so doing, find the best and most effective method of producing the required effect upon the patient.

PLATEAU'S FILMS.

THE forms assumed by liquids when all external disturbing forces have been removed, or, what is for practical purposes much the same thing, when their influences have been balanced and neutralized, form an exceedingly interesting branch of physical research.* In connection with this subject the name of Dr. J. Plateau, F.R.S., Professor of Physics and Astronomy in the University of Ghent, must for ever be associated, for it is to his celebrated researches which are collected and recorded in his valuable work* upon the subject that the world is mainly indebted for what it knows about it.

In order to see how a liquid would behave if freed from the influence of gravitation and of other disturbing influences, he immersed within one liquid a small quantity of another with which it would not mix, and which, moreover, was of precisely the same specific gravity. The substance known as olive oil is lighter than water, but heavier than alcohol, and with neither is it capable of entering into chemical composition, that is to say, olive oil will float if dropped

Fig. 1.

Fig. 2.

into water, but if introduced into a vessel containing alcohol it will sink and rest at the bottom. Taking advantage of these mutual properties, Dr. Plateau made a mixture of alcohol and water, whose specific gravity was exactly the same as the olive oil which he employed. A small portion, therefore, of the latter substance introduced into the alcoholic mixture would neither sink nor float, but would remain suspended in the mixture; it would, in fact, relatively to the forces acting upon it, be exactly in the same condition as an equal mass of the alcoholic mixture whose place it would occupy, and all influence of gravity would be completely eliminated. When this is the case the mass of oil assumes a perfectly spherical form and resembles to a certain extent a planet floating in space. By a suitable mechanical contrivance Professor Plateau succeeded in imparting to a liquid sphere of oil so suspended a rotary motion; when, obeying the laws of centrifugal force, the sphere became a spheroid flattened in its axis of rotation and extended in its equatorial dimensions. If the velocity of rotation be increased a curious phenomenon presents itself. The spheroid continues to become flatter and flatter at the poles, and larger and larger in its horizontal diameter, until a decided depression is formed around its central axis at both the top and the bottom of the mass of oil, and finally the latter separates from its central portion, becoming a perfectly regular ring, having a circle for its genitrix. In this stage it bears a very close analogy to the planet Saturn, having a central sphere with a circular ring around it a small distance from its equatorial circumference, the whole system rotating together; but there the similarity ceases, for although in his earlier memoirs Dr. Plateau conceived the possibility of the experiment illustrating the formation of the ring of Saturn, he has long since abandoned that view of the question. There is, moreover, the very distinct difference, namely, that while the cross section of the ring of oil is circular, that of Saturn's ring is flat and rectangular. When the rotation is stopped the ring closes in to its center and again assumes the spherical form.

If the end of a fine tube be carefully introduced into the spherical mass of oil, and a small quantity of the alcoholic mixture be allowed to flow through the tube, the sphere of oil will increase in diameter, becoming a hollow sphere or bubble containing the same alcoholic mixture as that in which it is suspended, and a hollow liquid sphere of extreme thinness may with care be thus produced as much as 4 ins. in diameter, which is still more uninfluenced by the force of gravitation than even the thinnest soap bubble blown in air, for the elimination of the influence of gravity from a soap bubble can only be in proportion to the thinness of its film, whose intrinsic specific gravity must of necessity be identical with that of the soap solution of which it is composed, and is, of course, as much greater than that of the air with which it is surrounded. The oil film, however, is of precisely the same specific gravity as the alcoholic medium, and is, therefore, absolutely uninfluenced by any gravitating force, as it floats within the mixture.

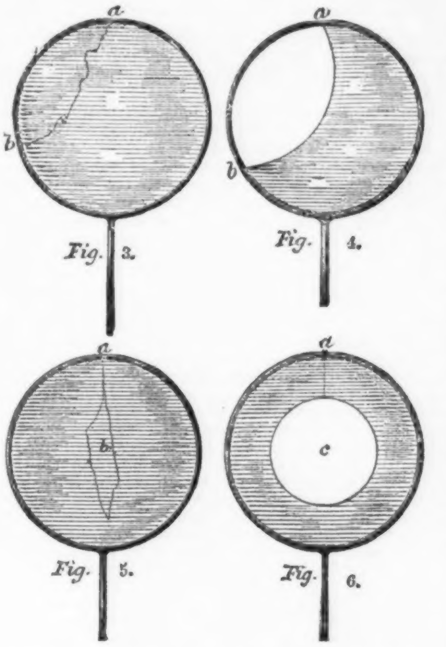


Fig. 3. Fig. 4. Fig. 5. Fig. 6.

For practical purposes, however, the phenomena by which the forms of thin liquid films are governed may be illustrated by films of soap solution, and of other substances which have such cohesive properties that they may be formed into pellicles or liquid films of a sufficient degree of attenuity to render their weight inappreciable with regard to that of the air; and by the employment, for this purpose, of soap solution in air, a large number of the difficulties of manipulation are avoided which are necessarily attendant upon the formation of films of oil in an alcoholic medium. A common solution of soap in water produces films which are, however, too evanescent to give satisfactory results, and Dr. Plateau found that a spherical soap bubble, 4 ins. in diameter, can seldom be preserved in the free air, within a room, for a longer time than two minutes,* a period far too short to enable an observer to study the attendant phenomena. He therefore used for the purpose a mixture of Marseilles soap, glycerine, and water, which he found produced films of great persistence; but various other formulæ for soap solutions have since been used by different experimenters, all depending upon the presence of glycerine for checking the evaporation of the water. We shall refer toward the close of this article to the more recent employment of other substances for the same purpose, by which the thin films may be rendered permanent.

If a simple flat ring of wire, two or three inches in diameter, and furnished with a stem or handle, be dipped into a glycerine solution of soap and quickly withdrawn, a flat film or bubble of soap solution will be formed across the ring, as shown in Fig. 1. Upon gently blowing upon a film so formed it will be inflated into a sort of bag (see Fig. 2), resembling in form an angler's landing-net, the depth of which will depend upon the tenacity of the solution, and upon the internal pressure within the envelope caused by the action of the breath. The moment the pressure is reduced the bag becomes smaller, and if the blowing be discontinued it will return to the flat form again as if it were composed of an elastic membrane, similar to the thin caoutchouc of which air-balls are composed. This simple experiment is an interesting example of the law which underruns all the phenomena connected with this research, namely, that a liquid film when under the influence of no external force has a tendency to contract into the smallest possible area of surface consistent with the form of boundary over which it is stretched. This may be illustrated in another way by the following very elegant experiments: Let a short length of cocoon silk be attached to two points, *a*

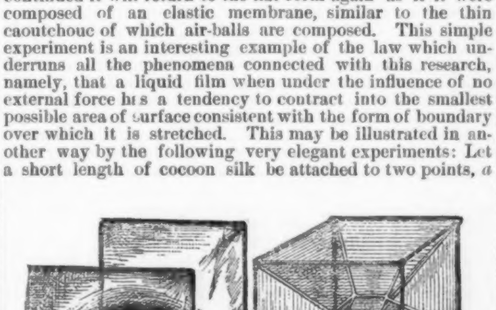


Fig. 8. Fig. 9.

and *b*, in the circumference of the ring so as to lie loosely between them (see Fig. 3), and across the ring let a soap film be formed, in which the filament, *a b*, will lie, dividing the film into two unequal portions. If now the smaller portion, that is to say, that part to the left of *a b* in the figure, be broken by a touch from the finger, the remaining portion becomes the only film, and immediately contracts to the smallest possible area consistent with its boundary, and as a part of this boundary, that is to say, the thread, *a b*, is free to move, it is dragged by the film into an arc of a circle, represented in Fig. 4. Again, if a loop of cocoon silk be suspended from a point in the circumference of the ring (see *a*, Fig. 5), and a film be formed across the whole, the latter will be divided into two portions, one within and the other outside the loop. If now the pellicle included within the loop be broken, the outside portion of the film will immediately contract, and in doing so will cause the loop to be dragged into a central circle, that being the form of largest area consistent with its boundary, and the annular film outside the loop will, in consequence, have contracted to the smallest area permitted by its closed boundary.

This property of contracting to the smallest area enables the films to solve what would otherwise be very complicated mathematical problems, for whatever may be the form of the closed boundary, the film formed over it will be the surface of least area, and, in some cases, most elaborate and beautiful forms are produced. It is, of course, obvious that the surface of least area inclosed by a flat circular ring, as in Fig. 1, must be a simple flat disk, but suppose the ring to be bent so as not to lie within a flat plane, if, for instance, it be curved by being bent over a cylinder of the same diameter as itself, and a film formed over it will present a surface of great beauty, and what at first may appear somewhat paradoxical, it will be at every point on either surface both convex and concave. The surface of least area is made apparent in this example by being looked at in its two symmetrical positions, when the curved film will be seen to occupy a mean position between the opposite curvatures of the ring.

Fig. 8 represents the film that is formed upon a frame of wire bent seven times at right angles to the form therein shown; the curvatures in this film are of great beauty, and, like the preceding example, are both convex and concave at every spot upon its surface.

The wire frames experimented with by Dr. Plateau were composed of iron wire 1 millimeter in diameter, and soldered together where necessary. Before describing the films formed upon skeleton frames of other shapes, we may mention that their great beauty—which their eminent discoverer never could enjoy in consequence of having lost his sight before the research was commenced—has induced several philosophers to try various substances capable of yielding permanent films, and which could therefore be studied at leisure and put away for future reference. Schwartz attempted to make them with a strong solution of gelatine. M. Rottier, of Ghent, employed a mixture which had previously been suggested by Böttger, consisting of eight parts of colophony resin and one of linseed oil. This mixture fuses at a temperature of 97° C., and with it films were produced, but they very soon broke. Mach employed a mixture of fused resin with an alkaline silicate, and the same experimenter imitated the forms produced naturally by the films, by stretching over wire frames a thin web of India rubber, and then exhausting the interior by means of an air syringe. Dr. Plateau suggested a mixture of five parts of resin to one of gutta-percha, but all these mixtures are far from satisfactory. It was reserved for Dr. Silvanus Thompson, Professor of Experimental Physics in University College, Bristol, to discover a substance which, when in the liquid state, possesses all the properties required for forming delicate films, and which, when solidified, has the property of retaining these films in their delicacy and transparency,

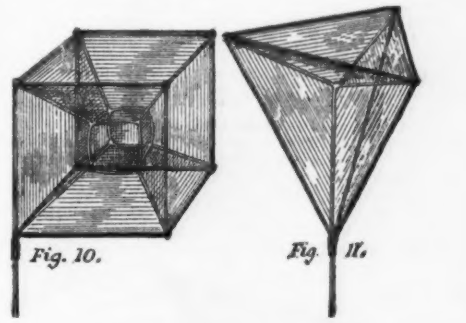


Fig. 10. Fig. 11.

possessing sufficient elasticity to prevent their becoming broken by expansion or otherwise.

The substance used by Dr. Thompson consists of a mixture of colophony resin and Canada balsam in the proportion of 46 per cent. of resin to 54 per cent. of Canada balsam, a few drops of spirits of turpentine being added after. With this mixture the best films are formed at a temperature of 95° C.; below that temperature they are thick and clumsy, and above it they are too thin and fragile, although it is possible to obtain a film from this compound at as high a temperature as 110° C., but it usually bursts before hardening. The tenacity of a film composed of this mixture is very great, in instance of which we may mention that a film formed across a horizontal ring an inch and a half in diameter, composed of iron wire ·035 in. in diameter, sustained, without breaking, the pressure of a circular brass 50 grammes weight (1·765 oz.) of about 1 in. in diameter placed upon its center.

The illustrations which accompany this article were drawn from films made with Professor Thompson's mixture, and there is no doubt that with ordinary care they may be preserved for many years. The frames are composed of brass wire No. 30 B.W.G., and the sides of the cubical frames are about 1 in. long.

If a simple skeleton cube be dipped into a mixture capable of forming persistent bubbles, instead of the sides becoming glazed, as it were, by plane films, a figure, shown in Fig. 9, is produced composed of a system of transparent flat films attached to the skeleton frames at its edges, but united to one another by liquid edges represented by the white lines in the figure. It is a remarkable fact that the films within the cube do not unite in a common center, but to a little flat square film which is invariably produced, sometimes in a vertical position and sometimes horizontal. This fact is an example of two laws discovered by Dr. Plateau, (1) that at one and the same liquid edge never more than three films can meet, and they are inclined to each other at equal angles, and (2) that when several liquid edges meet at one and the same point in the interior of a system, these edges are always four in number, and are inclined to each other at the point in question at equal angles.

If, immediately after forming the figure shown in Fig. 9, the top square of the cube be again dipped in the soap solution or resinous compound, a portion of air will be inclosed in the truncated pyramid of which that square is the base, and this air rising in the form of a bubble will take the

* "Statique expérimentale et théorique des Liquides soumis aux seules Forces moléculaire." Paris, 1873.

* "Annales de Chimie et de Physique," tome lxi., page 213.

place of the little square film in the center of the system, and will itself take the form of a little cube concentric with the frame, and having slightly convex sides. This form is shown in Fig. 10, and requires some practice to obtain in a perfect state with the resinous mixture, but it will repay a little patience devoted to it.

Fig. 11 is the system formed by dipping an equilateral tetrahedron into the film solution. In this case a set of triangular films is formed, having for their bases the wire edges of the skeleton frame, and having a common apex at its center. If, however, the top triangle be again dipped in the substance, as in the second experiment with the cube, the rising bubble takes the form of a little convex-sided tetrahedron with liquid edges concentric with the form of the wire skeleton. This figure is shown in Fig. 12, and will repay some trouble spent upon producing a good example.

Fig. 13 is a film formed upon a wire frame, which is constructed by first stretching a ring until it assumes the form of a long oval with straight sides and semi-circular ends, and then rolling the frame so produced into a spiral; this figure, which is due to Professor Thompson, gives a characteristic and very beautiful curve, for the surface of least area formed on such a frame necessitates the concavity of its external surface in a vertical direction, while the spiral form of the frame gives to the film an external concavity in a horizontal direction. The frame, Fig. 14, is formed by bending a wire four times at an angle of 60°, so as to produce a skeleton resembling that of a young bird's beak when gaping rather wide; the film formed upon this frame is very curious and is very difficult to represent in an engraving. A film of great beauty is shown in Fig. 15. For this example a frame is constructed by attaching by horizontal wires to a central vertical wire a spiral wire winding round the central wire as an axis. Upon dipping this in the film material a liquid screw is formed upon the frame, and the number of turns, or rather the length of the screw, is only limited by the depth of the solution into which it has to be dipped.

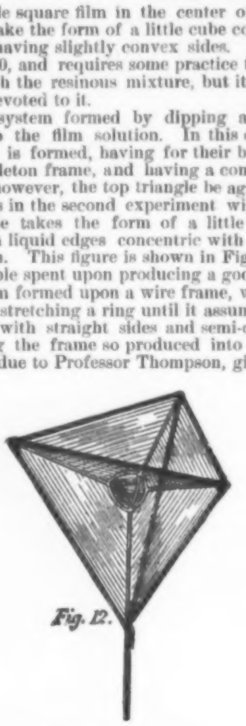


Fig. 12.

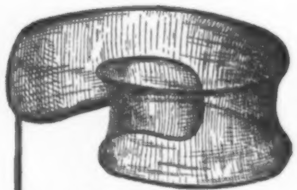


Fig. 13.

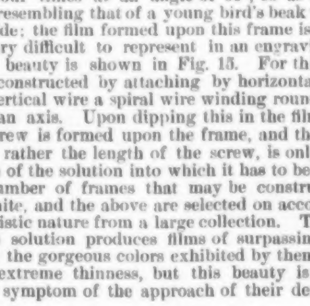


Fig. 14.

Fig. 15.

The number of frames that may be constructed is well nigh infinite, and the above are selected on account of their characteristic nature from a large collection. The glycerine and soap solution produces films of surpassing beauty by reason of the gorgeous colors exhibited by them on account of their extreme thinness, but this beauty is only a premonitory symptom of the approach of their death, for very soon after the colors exhibit themselves on a film the latter bursts, and nothing is left but the frame. By using, however, the mixture suggested by Professor Thompson, the films may be preserved in all their beauty of form for years, but they are almost colorless and appear to be composed of excessively thin glass, perfectly transparent and of a slightly yellowish tinge.

We need hardly add that Dr. Plateau's researches are of long standing, some of the experiments we have described having been made twenty years ago, but the subject is very little known, and, with one exception, appears to be ignored in text-books, and even there the name of Dr. Plateau does not appear. The new aspect of the subject is the discovery by Professor Thompson of a substance capable of retaining the films in their original beauty for an indefinite time, and we hope this will be taken advantage of for preserving in physical museums and other places available for students collections of characteristic specimens illustrating a branch of physical science that has been neglected, but which is second to none for the interest and beauty of its illustrative experiments.—*Engineering.*

CHEMICAL NOVELTIES.

Griffith's Paint.—It is well known that Mr. T. Griffith, of Liverpool, has invented a white paint, obtained by mixing solutions of sulphuret of barium and sulphate of zinc (white vitriol). The patentee ignites this precipitate with exclusion of air, and adds to the mixture ¼ its weight of magnesia, which, after the addition of oil, is said to increase its power of covering. Dr. Biedermann, commenting on the above patent in the *Berichte* of the Berlin Chemical Society, declares that the above white precipitate has "long been known and used."

Manufacture of Gelatine.—Sahlström treats fish offal with chloride of lime, then with permanganate of potash and with nitrous or sulphurous acid gas, and obtains good gelatine by boiling.

Tartaric Acid.—Dietrich and Schnitzer heat the residues of wine-making to 328°, and thus coagulate yeast, mucus, etc., so as to yield a purer tartaric acid.

Zinc Pigments.—C. A. F. Meissner, of Schöningen, proposes the following method of preparing sulphuret of zinc pigments free from uncombined sulphur and from basic sulphate of zinc. The precipitates and mixtures containing zinc are roasted in a muffle into which superheated steam is forced under a considerable pressure at the side opposite to the draught. With steam of at least 750° F. driven into a muffle at a white heat, sulphuret of zinc can be entirely converted into oxide of zinc. The precipitates of sulphuret of zinc prepared by adding alkaline sulphurets to solutions of white vitriol and other commercial salts, or waste solutions of zinc, and commonly used as white opaque pigment-colors, contain a by no means insignificant quantity of sulphur, which is then roasted off in the course of the manufacture. Here there has been hitherto the choice between two evils. Either the roasting off has been too slight, so that free sulphur remained in the finished product, and occasioned mischief if used along with any color or varnish containing lead; or else the roasting has been so strong as to decompose the sulphuret of zinc, and with the aid of the current of air inevitable in the common process to convert a portion of it into the insoluble basic sulphate of zinc, which injures both the color and the dyeing power of the product. Superheated steam quickly and completely converts all free sulphur into vapors of sulphurous acid, which are at once swept away, while atmospheric air is at the same time excluded. If the heat is too strong, a portion of the sulphuret is converted into oxide, while in any case the product can contain neither free sulphur nor basic sulphate.

Aureosine Colors.—E. Willm, G. Bouchardat, and Ch. Girard, of Paris, propose to manufacture coloring matters by the action of the hypochlorites upon phthaleines. As Baeyer has already obtained certain dyes by the action of bromine upon fluoresceine, the inventors make use of chlorine or the hypochlorites, letting them act upon phthaleines, or, indeed, generally speaking, upon the products of the reaction of bibasic acids upon phenoles and diphenoles. They take, for instance, 2 lbs. 3 ozs. fluoresceine, dissolve it in 17⅙ pints of cold water, with a slight excess of caustic soda, and add then a solution of chloride of soda or chloride of lime. This solution must contain 3 lbs. 11 ozs. of chlorine, its value being ascertained by Guy-Lussac's process. The solution is then mixed with a slight excess of muriatic acid. Carbonic acid is evolved, and the mixture smells of chloroform. The precipitate is filtered off and washed with water, and is then pure enough for direct application. This substance is a chlorinized body, and is named by the inventors aureosine. It is insoluble in water, readily soluble in alkalies; the concentrated solution is brown; if somewhat diluted it becomes superficially green, but if strongly diluted it appears rose-colored, with a yellowish green dichroism by transmitted light.

Aureosine dyes silk and wool without mordant, producing the same colors. In order to dye it is first converted into an alkaline salt, soluble in water. It is then very slightly soured, and the flot is then ready for dyeing.

If aureosine is converted into a nitro-compound by means of nitric acid, or preferably, of nitrate of potash and glacial acetic acid, there is formed rubeosine, a splendid red coloring matter. It remains chiefly dissolved in the acetic acid, but is completely precipitated by the addition of water. It requires then merely to be filtered, washed with water, and dried.

For use in dyeing one part of it is dissolved in the solution of two-thirds parts of carbonate of soda in 100 parts of water. The solution is slightly soured, then heated, and is fit for use.

Rosaniline Acid Colors.—The Baden Aniline and Soda Works of Mannheim patent a process for the preparation of the sulpho-acid compounds of rosaniline, of the methyl violets, and similar coloring matters, and for the conversion of these coloring matters into substitution-derivatives. For the production of the sulpho-acids the inventors make use of the bases from the manufacture of magenta and methyl-violet, further the substitution-derivatives obtained by the introduction of alcohol-radicals into rosaniline, as well as by the action of benzyl-chloride upon methyl-violet. For the formation of the sulpho-acids dry sulphuric acid or fuming oil of vitriol is used.

1. Sulphorosanilic acid is prepared as follows: 10 parts of rosaniline, dried at 282° Fahr., are dissolved in 40 parts of fuming sulphuric acid, containing 20 per cent. of the dry acid. The temperature must not fall below 248° Fahr., and not exceed 338° Fahr. The thick, sirupy mass should be readily soluble in water, and form a clear solution with alkalies. The product of the reaction is introduced into water, and super-saturated with milk of lime. The lime salt is then separated by filtration from the deposit of sulphate of lime, and converted into a soda salt by treatment with soda, and then evaporated to dryness. As the result is hygroscopic, it is better to prepare the acid salt by an addition of muriatic acid. Crude magenta melt may be used in place of pure rosaniline.

For the preparation of the sulpho-acid of methyl-violet, 10 parts of this color are added to 40 parts of fuming sulphuric acid, as before; but the temperature is kept between 212° Fahr. and 248° Fahr. As much more acid is added till the conversion is complete, the remainder of the process being conducted as described above. An excess of alkali must be avoided during the evaporation to dryness.

Substitution products are obtained by the action of the alcoholic halogen compounds (such as iodide of methyl) upon the sulpho-acids and their salts. Thus, 22 lbs. of the sulpho rosanilate of soda are mixed with 11 galls. of water, 11 galls. of alcohol, 26 ozs. of soda-lye, of specific gravity 1·38, with the addition of 2 lbs. 13 ozs. iodide of ethyl, and heated in a copper vessel fitted with a cohobater till a reddish violet color has been produced. The same weights of soda-lye and iodide of ethyl are again added, and so on till altogether 9 lbs. 18½ ozs. of soda-lye and 17 lbs. of iodide of ethyl have been used. The contents of the vessel are then neutralized with muriatic acid, and the alcohol is distilled off. The residue is then mixed with a watery solution of sulphurous acid. After settling for twelve hours, the iodine can be recovered from the liquid as iodide of copper. The filtrate, after expulsion of the sulphurous acid, is freed from the excess of copper by means of soda, and after acidulation is evaporated to dryness.

The great importance of these acid colors—the first of which we have repeatedly had to mention as "acid magenta"—is that they permit the use of acid mordants and alterants, and can be used to produce an almost unlimited series of mixture, with dye-wares of an acid character.

Preservation of Wood.—J. Jeyes, of Plaistow, proposes as a means for the preservation of wood, the destruction of vermin, etc., to melt together 100 lbs. of creosote or naphthaline, or a mixture of both, with an equal weight of rosin, and to add five gallons of soda-lye at 30° B.

Prussian Blue.—P. Spence, of Manchester, the eminent alum manufacturer, utilizes spent hydrated oxide of iron from the gas purifiers in the following ingenious manner: The oxide is first lixiviated with water in suitable tanks in order to extract any ammoniacal compounds which may be present, the residue being subsequently air-dried. A quantity of lime, equal to half the weight of the hydrate, is then slaked, and the hydrate thus obtained is thoroughly mixed with the iron. The mass is placed in double-bottomed iron vessels and lixiviated with warm water, not exceeding 158° Fahr. The solution slightly acidified yields Prussian blue on treatment with chloride of iron, which may be either used as such or converted into yellow prussiate. After the mass has thus given off all ferro-cyanide of lime present, it is boiled with water in the same vessels. It yields a solution of the polysulphurets of calcium, from which sulphur is precipitated on the addition of muriatic acid. The oxide of iron remaining can serve again for the purification of gas.

Sulphuric Acid.—J. A. W. Wolters, of Kalk, proposes to manufacture dry or anhydrous sulphuric acid by heating dry bisulphate of soda with dry epsoms. The dry bisulphate of soda is obtained by heating salt-cake with an equivalent of oil of vitriol, and it reacts upon the epsoms at a temperature which is just sufficient to keep it liquid. A double compound of the two salts is formed, while the dry acid, SO_3, distills over on a slight rise of temperature. The double compound above mentioned is resolved into its original constituent salts by crystallization, and after the addition of a fresh quantity of oil of vitriol may serve over again. The chief value of this process lies in the fact that the dry acid is obtained at a relatively low temperature, that the plant is thus preserved from destruction, and that the yield is very high. Dry sulphuric acid is now an important ingredient in the manufacture of certain artificial coloring matters.

Removing Iron from Clay.—H. B. Condy proposes a new process for removing iron from aluminous minerals. He effects this purpose by the reduction of the sparingly soluble salts of peroxide of iron present in clay, kaolin, etc. The reduction is effected by heating the clay in a closed furnace with the fixed sulphuret of an alkali or an alkaline earth, or it may be performed in the wet way by treatment with sulphureted hydrogen or a sulphuret. In the dry process instead of sulphuret of sodium salt-cake mixed with coke or charcoal may be employed. If a soluble but dry sulphuret, such as that of sodium, is employed in sufficient quantity, there is produced sulphuret of iron and a soluble compound of alumina, sulphur, and soda, which the inventor designates as sulpho aluminate of soda. Its solution is treated with carbonic acid; when sulphureted hydrogen escapes, carbonate of soda is formed, and pure alumina is precipitated.

If it be desired to extract the iron without forming the compound above mentioned, the bauxite or other mineral, finely ground, is suspended in water, and treated with sulphureted hydrogen or a soluble sulphuret. The oxide of iron is thus converted into sulphide, which may then be removed by digestion with dilute muriatic acid, decantation, and washing.—*Chemical Review.*

ELECTRO-GILDING.

The Gilding Bath.—The gold plater's bath is prepared from gold oxide, potassium cyanide, and soft water. The proportion of these is usually about as follows:

Potassium cyanide	14 to 16 ounces.
Water	1 gallon.
Gold oxide	½ ounce.

For large articles the proportion of gold may be greater; for small articles somewhat less. The solution should be made and kept in a porcelain or well glazed earthen vessel. The gold oxide may be prepared by heating in a small porcelain capsule or dish to about 130° Fahr. over a water bath,

Fine gold	1 part.
Aqua regia, about	20 parts.

The aqua regia consists of a mixture of nitric and hydrochloric acids in the proportion of one part of the former to three parts of the latter. When the gold has dissolved the solution is digested for a time with a slight excess of calcined magnesia and the precipitated gold oxide, treated with a small quantity of strong, hot nitric acid to remove the remaining magnesia, etc., washed with clean water and dried. The nitric acid dissolves a trace of gold, and should be kept for use again.

Articles of copper, brass, or German silver, that are to be plated should first be boiled for a few minutes in a strong solution of caustic potash or soda (preferably the former). This solution may be prepared from

Caustic potassa	5 pounds.
Water	1 gallon.

The grease, etc., having thus been removed, the articles should be rinsed in clean water, and transferred for a few minutes to the acid dip, which may be composed of

Nitric acid	6½ pounds.
Water	1 gallon.

This removes any oxide from the surface, and after quickly rinsing in water to remove traces of acid, the article should be securely fixed to the end of a copper wire double hook convenient for suspending it in the baths. In many cases this trussing is preferably made the preliminary step in the proceedings. When the work is properly cleaned and trussed, and the bath is not ready for its reception, it should be suspended in clean water, and there remain until it is taken out to be placed in the brightening dip. This may be composed of strong nitric acid, or, what is thought by platers to be preferable, a mixture of

Nitric acid (commercial)	6 pounds.
Sulphuric acid " about	4½ "

The work is dipped in this only for a moment or two and then quickly rinsed in clean water and transferred immediately to the plating bath, where it is suspended by the clean truss hook from the copper rod in connection with the zinc pole of the battery. Where the article to be gilded is of silver it should not be dipped in this last bath. The feeding plates or anodes used are, of course, of gold.

The bath should be hot while the work is in it, and, other things being equal, the hotter the solution the less battery power will be required. For gilding silver a temperature of 200° Fahr. is recommended, and for gilding copper about 130°. From three to five minutes' suspension in the solution only is required under favorable circumstances to gild the work properly. As the solution is used hot it undergoes rapid evaporation, and must, therefore, be replenished from time to time with fresh water, but not during the operation of gilding.

When the bath is working properly the gold anodes should remain constantly clear; a green film or incrustation indicates an insufficiency of potassium cyanide; if they become covered with a black slime too little surface of anode is exposed to the bath. The surface of the gilded article on coming from the bath should present to the eye a dark yellow color approaching to brown, and this when scratched with the nail should present a rich deep-gold hue.

If the color of the surface is blackish the battery employed is too strong. Work thus blackened cannot be properly finished with the brush and burnisher; the article must be cleaned again.

Coloring.—If the solution is too cold and the battery weak the deposit will be very light colored. The color may be heightened by covering with a paste of

Potassium nitrate	2 parts.
Alum	1 "
Zinc sulphate	1 "
Water	q. s.

triturated in a mortar, and then heating the article in a muffle (or, if small, on an iron plate) just short of low redness (dark heat).

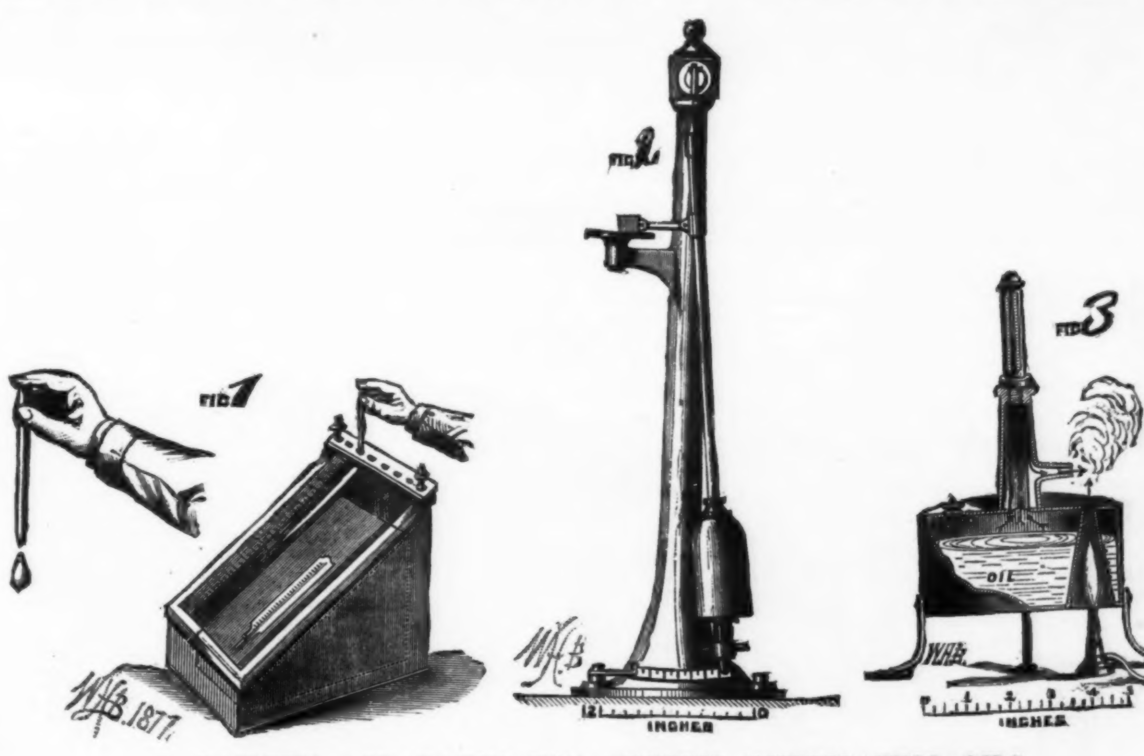
A visible film of gold may be imparted to an article when properly cleansed and connected with the battery by dipping it in the bath and immediately withdrawing it; but the durability of such a deposit is necessarily very transient, and if the article be of white metal or silver the deposit will be rather light-colored.

BAILEY'S APPARATUS FOR TESTING LUBRICATING OILS.

FIG. 1 represents an apparatus by W. H. Bailey, of Salford, Manchester, England, to test the consistence of oils and examine their behavior at different temperatures. Few oils only give perfect satisfaction in this direction, as at certain temperatures they either solidify or acquire a watery consistence, in both cases losing their lubricating power. The apparatus consists of a case with a glass cover. Within there is a thermometer indicating the temperature, and a scale is laid down on one side, by which is measured the distance traversed by a drop of oil placed near the upper end of the glass cover. A door is provided in the rear end of the case, through which a vessel with boiling water may be introduced to elevate the temperature. To prevent it from cooling down too fast, the case is lined with felt.

A very good apparatus for examining cylinder, clock, spindle and sewing machine oils is represented in Fig 2. From the top of a stout pillar is suspended a pendulum, which swings freely in front of a scale provided at the base of the pillar. The arm of the pendulum is provided with a link, transmitting the oscillating motion to a piece of brass, sliding on a plate of the same material. One or two drops of a standard oil are placed on the plate and the pendulum is made to swing. The number of oscillations made before standing still being noted, the standard oil on the plate is replaced by the oil to be examined. The pendulum is again caused to swing with the same initial velocity, when, the number of oscillations being again counted, an inference may be drawn from the difference in the numbers in each case as to the lubricating power of the oils. A tendency of the oil to gum or oxidize on exposure to air may be detected by testing the oil when fresh and then leaving it on the apparatus for a few days. The slightest change in the oil will be immediately detected. This instrument is of good service when the steam necessary for Thurston's and Stapper's apparatus is not to be had.

Fig. 3 represents a simple apparatus for determining the temperature at which an oil evaporates. Lubricants must be able to absorb a large amount of heat, and must consequently evaporate at high temperatures only; an oil not possessing these properties loses its antifrictional power in a heated journal and tends to increase the heat. Light mineral oils are especially dangerous, as their vapor is easily ignited and may cause great conflagrations. The drawing explains itself. The cylindrical boiler rests on a tripod, while a conical opening extends through the same from the top to the bottom, wide enough to admit the flame of a Bunsen burner. From the center of the upper surface a conical tube about three inches high emerges, in which is lightly inserted a thermometer, the bulb of which reaches to a point nearly opposite a small lateral, conical tube, through which the vapors are, after coming in contact with the thermometer, allowed to escape. The boiler is partially filled with the oil through an opening closed by a screw cover. Heat is then applied, and as soon as the first trace of vapor is observed the temperature may be read off.



BAILEY'S APPARATUS FOR TESTING LUBRICATING OILS.

GLYCERINE.

By E. DONATH.

THE property of glycerine to dissolve certain metallic oxides and hydroxides, and to prevent the precipitation of others by alkalies, has been known for some time past already. It is probably due to the formation of metallic glycerides. In trying to find a suitable reagent to determine glycerine quantitatively, the author treated a series of metallic oxides with a glyceride of soda, consisting of equal parts by measure of glycerine and a solution of caustic soda of 1·2.

This solution possesses the property to dissolve the higher oxides of some metals. The precipitation of sesquioxide of manganese is thus not prevented by the glycerine, but, on exposing the precipitate to the air, it is redissolved, forming a deep cherry red solution, having been further oxidized. The same result is obtained when the precipitate formed by warming a solution of a salt of manganese and hypochlorite of sodium is brought into the glyceride. The precipitation of salts of nickel and cobalt by potassa is not prevented by glycerine. Mixtures of glycerine and caustic soda possess pronounced reducing properties. Black, hydrated oxide of nickel, as obtained by the reaction of hypochlorite of soda on nickel solutions, is reduced already at ordinary temperature to green, hydrated sesquioxide. The same reaction takes place on oxide of cobalt, when heat is applied.

If a mixture of glycerine and ammonia, containing a small quantity of chloride of ammonium is used instead of the soda glyceride, the hydrated oxide of nickel is immediately dissolved, forming a blue liquid, while the cobalt oxide only dissolves sparingly and only after the lapse of considerable time.

This difference in the behavior of the two oxides may be used to separate the two metals. The solution containing the metals is boiled with hypochlorite of soda. Hereby the oxides are precipitated in the form of a black, granular deposit. The latter is well washed out and shaken well in a mixture of glycerine and ammonia. The liquid is then transferred to a filter, and the remaining precipitate washed out well, when the filtrate will contain all the nickel in solution, the cobalt oxide remaining behind.

The glyceride of soda behaves similarly to the hydrated copper oxide, when mixed with cadmium oxide, and the reaction may therefore be used to separate the two metals in quantitative and qualitative analysis.

To this effect the metals, in the form of sulphurets, are dissolved in warm, dilute nitric acid, and the glyceride of soda added in excess. A deep blue solution is formed, which will be altogether clear when copper alone was present, but will show a sediment of hydrated calcium oxide, in case that metal was present.—*Dingler's Poly. Journal.*

CALIFORNIA has a profitable and growing cheese trade with China, Australia, and South America.

SPECTRAL ANALYSIS AND THE IDENTITY OF CHEMICAL ELEMENTS.

MR. LOCKYER, a well-known member of the Paris Academy of Sciences, has advanced the theory that all the bodies recognized as elements, and their various combinations, are identical with hydrogen, the elements being merely allotropic modifications of the latter. At this conclusion he has arrived, by close study, for a number of years, of the spectra of all the elements and their combinations, under variable degrees of pressure, and surrounded by different mediums, and by comparing the spectra with those of the different bodies.

Mr. Lockyer has as yet not published any details, but has promised to do so soon, at a late meeting of the Academy. If he is able to prove the correctness of his theory a great progress will have been made in chemical science.

Several facts speak evidently in favor of Mr. Lockyer's theory, as, for instance, the existence of several allotropic modifications of some elements the properties of which differ so widely that only the actual transformation of one into the other has convinced us of their identity.

Meanwhile the matter has been taken up by other chemists, and lately Mr. Ciamician has published the results of some interesting experiments made with the halogen group of elements.

The spectra of the latter have by him been found to vary considerably at different degrees of pressure and temperature. In the several spectra obtained some lines seemed to be permanent, however, while the greater number changed in color and position. The apparently permanent lines can be probably altered similarly by degrees of heat and pressure, which the author has so far been unable to produce in connection with the spectroscope.

Bromine gas was examined in rarefied condition. Its spectrum then resembled closely that of chlorine, the resemblance increasing with the degree of rarefaction. The spectrum furnished by compressed bromine vapor resembles that obtained from iodine.

Iodine, in moderately rarefied state, furnishes a spectrum analogous to that of bromine; when very highly rarefied the spectrum resembles that of chlorine. Very dense iodine vapor gives a peculiar spectrum, which cannot well be compared with that of other halogens.

The position of the lines of the spectra of these elements taken at the same degree of pressure is homologous. Those lines mostly variable at that pressure appear broad, but with indistinct outlines, while the more stable lines are narrow and sharply traced.

At high pressure and temperature the spectra of those elements are more considerably changed which possess the strongest chemical affinity.

MANUFACTURE OF ALUM.

By MM. A. GAUDIN and J. P. FONQUERGNE.

IF we boil a mixture of ferruginous sulphate of alumina, of sulphate of iron, and of iron alum in a cast-iron pan, the proportion of iron will augment, but with the production of nascent hydrogen, whose presence reduces all the iron to the lowest stage of oxidation; as soon as this solution ceases to redden paper saturated with sulphocyanide of ammonium it is concentrated and filtered, and a clear concentrated solution of sulphate of ammonia is added, when a white crystalline precipitate is deposited.

This white precipitate is ammoniacal alum free from iron, and it is carefully washed to remove every trace of the mother-liquor, which is extremely ferruginous.

Such, in all its simplicity, is the series of operations employed for obtaining alum free from iron; the result being reached by the apparently paradoxical use of vessels of iron.

Whatever may be the proportion of iron originally present in a sulphate of alumina, this process enables us to manufacture ammoniacal alum free from iron.

If we have to do with sulphates of alumina poor in iron, we may either use iron pans or wooden vessels heated by steam and containing iron-turnings. If the solutions are very rich in iron, its proportion must not be needlessly increased.

For the reduction of aluminous sulphates very rich in iron, agents must be employed as economical and effective as iron, such as sawdust, which requires that the temperature of the mixture should be raised to the carbonization of the reducing agents.

If in spite of this operation the reduction of the aluminous solution is not complete, we employ alkaline sulphites, hyposulphites, or sulphurous acid.

These methods for reducing iron to the lowest stage of oxidation are applicable to solutions of alum, as well as to those of sulphate of alumina.

The solutions which contain iron reduced to its minimum stage preserve their condition indefinitely if not exposed to the air; alum may be obtained, therefore, either in blocks or in powder. Still by reason of the possibility of the mother-liquor remaining lodged among the crystals an iron free alum can only be obtained by this process in the state of granules.—*Teinturier Pratique.*

A FAST STEEL YACHT

THE Cherie, constructed throughout by Mr. D. J. Lewin, of Victoria wharf, Fulham, London, received the silver medal at Paris. Her length is 51 feet over all; breadth of beam, 7 feet 6 inches; and displacement, 15 tons. The draught of water aft, with a full complement of twenty-five passengers besides the captain and engineer, and with the bunkers full, is about 3 feet. The vessel is built in four parts entirely of steel, the plates being $\frac{1}{8}$ inch thick, with an inner lining of teak. The little craft can, by means of her engines and tiller, be easily turned round in her own length. The screw, 3 feet 2 inches in diameter, is of cast iron, and has three pear-shaped blades. The screw shaft, $2\frac{1}{8}$ inches in diameter, is, like the engines, made of steel for securing combined strength with lightness.

The engines (Fig. 2) are of the steam hammer type, consisting of a pair of inverted direct acting cylinders of $6\frac{1}{2}$ inches diameter and 7 inches stroke, erected on turned steel columns. They are fitted with reversible link motion, and with very neat arrangements for lubricating every part. A point worthy of notice is that the feed, blow-off, and other cocks, are conveniently placed within reach of the engineer. All the bearings are of brass lined with white metal, so as to avoid any chance of heating. This difficulty, we are assured, never occurred during the six months that the yacht was at Paris, making several trips daily up and down the Seine; on the contrary, the engines ran as well on the last day as at first starting.

The boiler is of the locomotive type, tested to 220 lbs., with 100 tubes, $1\frac{1}{2}$ inches in diameter, giving, with the fire-box, a large amount of heating surface. The consumption of fuel is about 40 lbs. of hard Welsh steam coal per hour; and the run from the Pont d'Iena to St. Cloud, a distance of about seven miles, has frequently been made without charging the furnace, after starting with a good head of steam. The speed of this launch when tried before leaving England was 16 miles an hour.

Both fore and aft cockpits are luxuriously fitted with Brussels carpets and reversible cushions of velvet and leather. The cabin is constructed of teak, ornamented with maple. It is provided with Armstrong & Co.'s patent marine "under line" w. c., in which one pump forces the waste under the bilge and away to stern, while another introduces the fresh water. By way of economizing space, a wash basin set in a frame with hinges comes down on the top when required for use. There is also an ingenious arrangement for securing the cabin windows.

We may safely affirm, in conclusion, that the Cherie is as swift, compact and comfortable a little craft as ever "walked the waters a thing of life;" and she was also pronounced "superb" by H. R. H. the Prince of Wales, who made a trip in her on 19th July last from St. Cloud to the Exhibition.—*Iron.*

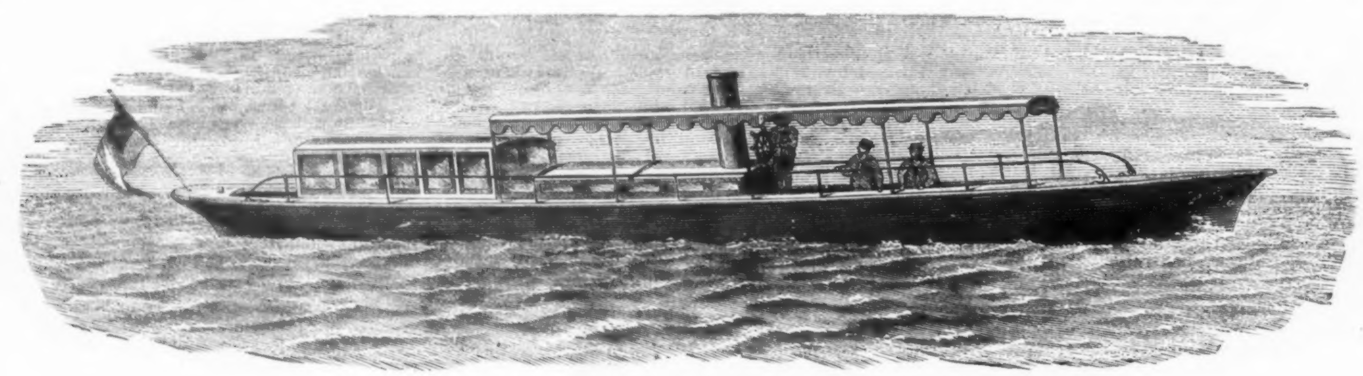


FIG. 1.—A FAST STEEL YACHT.

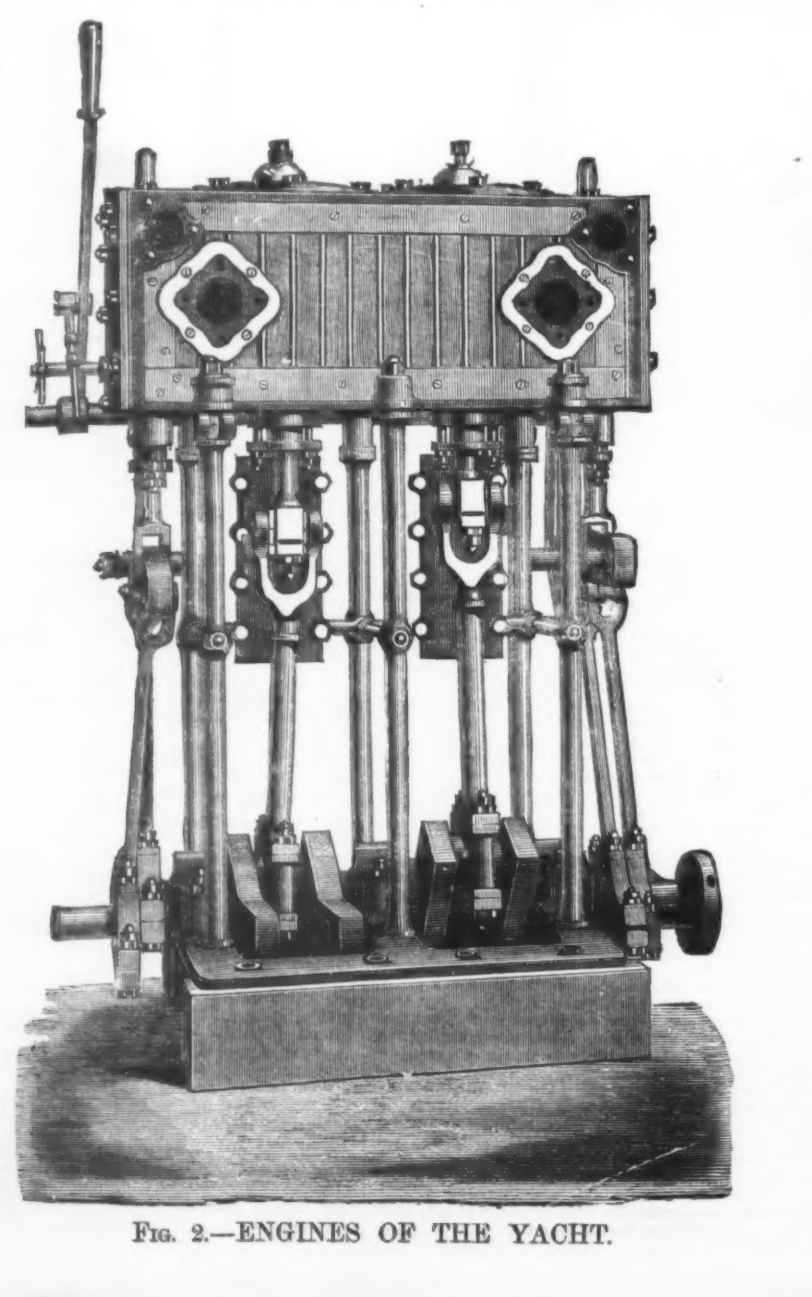


FIG. 2.—ENGINES OF THE YACHT.

ECONOMY OF FUEL AND PREVENTION OF SMOKE.

IN Mr. Bourne's comprehensive treatise on Steam and Gas Engines, reviewed by us the other day, some valuable data are furnished in the appendix respecting the best form of boiler to prevent smoke, and the best means of firing, the main conclusions of which may be of interest to builders and contractors using steam power. Extensives series of experiments on the evaporative power of various descriptions of coal and forms of boiler were carried on at Wigan a few years ago. Coal-proprietors and boiler-makers were invited to co-operate in these trials, and the result showed that the South Lancashire and Cheshire coals had a high economic value, and were able to evaporate 11·28 lbs. of water at 100° to 1 lb. of coal, without making any smoke beyond a slight trace. But the subject has more interest for us when we search into the result of these inquiries as they affect the form of boilers and the mode of firing usually adopted. In the experiments a two flued boiler with steel tubes, one with iron tubes, and a conical water tube boiler were tried, and to make a fair trial of these the best mode of firing had to be considered.

Three modes of firing were adopted—the "spreading" firing, the "coking" firing, and the "alternate side" firing. The first, or "spreading," is that usually employed, and makes so much smoke. It consists in scattering the fuel over the whole fire, beginning at the bridge and then gradually working forwards to the fire door, while the second or "coking" plan is to heap the fuel on the dead plate in front of the furnace, the crust of which, after being coked, is pushed back and a fresh charge of coal is placed in front again, while the "alternate" side plan is to place the coal on one side only, so that one side of the fire is black while the other is bright, and to change sides alternately. The result of the three systems was in favor of "coking firing" as evolving less smoke, though side firing appeared of advantage with "slack." Comparing the boilers, the results obtained are given as follows: "The patent conical water-tube boiler is not practically superior to the plain two-flued as regards prevention of smoke; nor is the plain two-flued practically superior to the patent conical water-tube boiler." The steel flued boiler appeared to have no advantage over the iron, so that as regards economy, speed of evaporation, and prevention of smoke, any of the three boilers was practically as good as the other.

Speaking of mechanical firing, the report favorably mentions Messrs. Vicars' (of Liverpool) self-feeding fire-grate, applicable to boilers fixed externally or internally, which proved very successful in the prevention of smoke as well as economy of evaporation, but when firing with round coal it had no superiority over hand firing. Of the merits of round and slack coal it has been found that there is a loss in the use of slack coal, and that by its use either speed must be sacrificed or smoke made. On the vexed question, which is the best part of the furnace to admit the air, at the door or at the bridge, it was decided that no practical difference is found to exist. With regard to the form of boilers, the report says, in conclusion: "It has been found that those of the plain two-flued construction, aided by a water-heater, are able to develop a very high result. We have evaporated as much as $10\frac{1}{2}$ lbs. of water at 100° by 1 lb. of coal, on a fire-grate 4 ft. in length, and $10\frac{1}{2}$ lbs. on a fire-grate 6 ft. in length. In both cases this has been done without smoke."

These experiments, imperfect as they are, show smoke may be prevented, whether mechanical or hand firing is used, without special appliances, or when the combustion of the gases is assisted by driving in currents of air by jets of steam, the smoke nuisance may be much abated. Coking has a great deal to do with the result. Firing is an art, and to a large extent smoke-producers are the stokers, and we quite agree with the remark, "Educate the stokers in their art, and smoke will be prevented." At the same time hand stoking will soon be a thing of the past, and some mechanical method of feeding the furnace continuously will obviate the nuisance.—*Building News.*

SINGULAR CASE OF HEATING IN A BAR OF IRON.—M. Hirn.—The writer describes a case where a bar of iron, struck with a sledge-hammer at one of its extremities, underwent at every blow a rise of temperature to the extent of about 30°, returning immediately to its former heat. He considers that, in certain particular conditions, sonorous vibrations, shaking the nerves of sensation, may determine at the periphery of the human body a sensation of heat, just as a pressure upon the eyes produces in them a sensation of light.

IMPROVED APPARATUS FOR LAUNCHING BOATS.

MR. ERNST L. OPPENHEIM, U. S. Consul at Gothenburg, Sweden, sends us a description and drawings of an improved apparatus for launching boats from vessels in case of accidents. It is the invention of Mr. Albert Magnus, a merchant of Gothenburg, who will, however, not apply for a patent for it or draw any pecuniary benefit from it, but declares to be satisfied, if, through its adoption by shipowners, the loss of life, attending the launching of boats amidst the disorder and excitement prevailing on such occasions, is materially lessened.

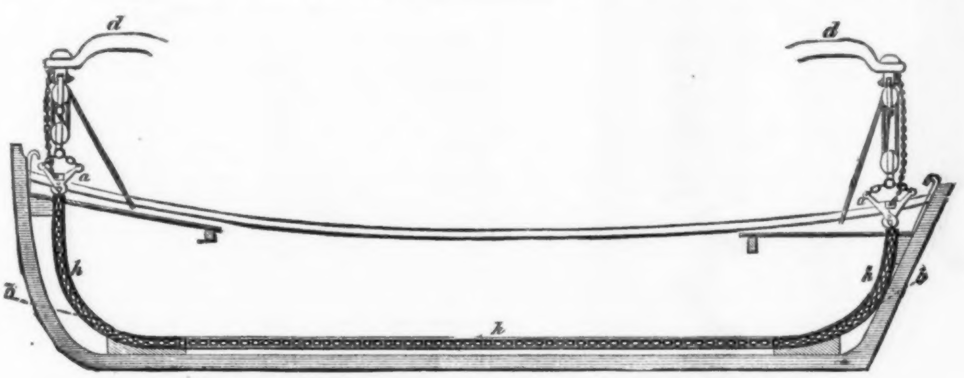
Frequently the boats must be lowered while the vessel is in motion; in this case, both ends of the lifeboat must be released simultaneously, as otherwise the boat, on reaching the surface of the water, receives a sudden jerk forward, fills with water and capsizes. In Mr. Magnus' apparatus this danger is completely avoided, the boat being automatically released at each end.

Instead of being suspended by hooks and rings, the boat is held by tongues, *a*, and a chain, *b*. The latter passes through a tube, running along the keel of the boat. The tongues are kept closed by the own weight of the boat, while the springs, *c*, tend to open them. Thus it will be seen that, the boat being lowered, its weight is taken up by the water, the strain on the tongues relaxes, the springs open the same and the chain is released. Thus, all connection with the ship is broken precisely at the moment when the boat reaches the water.

By high waves reaching and lifting up the boats, the same result might be produced and the boats lost. To prevent this, a lock, *e*, is provided, which is opened and closed by a bolt attached to a chain, *g*. The latter is fastened to the davit, and of such a length that it acts on the bolt and opens the lock exactly at the moment when, the boat being lowered, the tongues open. When, therefore, it should have been forgotten to open the lock in the excitement of the moment, it opens automatically.

If one of the tongues does not open for some reason, after the boat has been launched, the chain, one end being free, is easily drawn from the tube through which it passes, and thus the boat will be let loose, whereby a ready detachment of the boat is rendered absolutely certain.

Mr. Magnus states that much annoyance and danger are due to the fact that the iron parts of the lowering apparatus corrode rapidly under the action of salt water. He therefore proposes to substitute bronze for iron.



NEW APPARATUS FOR LAUNCHING BOATS.

[Continued from SUPPLEMENTS Nos. 156, 157, 158, 159.]

ARTESIAN WELLS.

THE following tools represented are patented, and the cuts of the same copyrighted, by Charles D. Pierce, manager of the Pierce Well Excavator Company, No. 4206 Elm avenue, Philadelphia, Pa.

Figs. 1 and 3 represent two views of a 17-inch auger. The shells or pods are made of quarter inch iron plate. The lower portions of these pods, after forming the cup-like curve, are shod with knives or cutters, which are inclined in two directions, so that when the auger is revolved they will engage the earth at the inner corners first, and cut down gradually with a draw-cut. The outside points stand farther than any other portion from the center of the apparatus, as is indicated by the dotted circles. Thus so small a portion of the auger touches the side of the bore-hole, that there is a minimum of friction. Moreover, free access of the air to the space beneath the auger is allowed, so that when the latter is drawn up no suction will interfere. Other devices have been tried to overcome this suction; the edge of the shell has been turned over, forming an air-tube; pipes have been used; the side of the shell has been flattened, but with no flattering success, as the air passages so formed are soon filled with debris. The dots on the edge of the pods show where sand-sides and valves may be attached, thus converting the auger into a pump. These attachments are necessary in boring in quicksand. When great distances must be sunk through quicksand a curb is put in, and the boring continued through this. The cutters are of ⅜-inch steel, and so fastened with rivets that they may be removed and new ones substituted. The shells are attached to cast-steel arms, which are hinged so that when the auger is drawn up full, and the collars or bands (shown in cuts) slipped up, the shells swing open, and the debris falls out. It is said that this auger will bore through anything except solid, hard rock.

Fig. 5 represents an 18-inch auger, the construction of which can be gathered from the cut. Fig. 4 shows the same, with the sand-sides and valves attached. In both cuts the marginal dotted lines indicate the size of the bore-hole, no part of the tool but the outer points of the cutters being allowed to touch the sides of the hole. The key, B, Fig. 4, can be removed so that the shells may be spread, either to discharge debris or to admit of the entrance of rocks nearly the size of the borehole. The valves, Fig. 4, are hinged about E, the dark dotted lines showing them closed, the lighter lines indicating their position when open. The position of their axis is shown by the dotted diameter in the horizontal projection below Fig. 4. The valves may be lifted up for discharging purposes by means of the rod F, Fig. 4. Only one valve need be lifted, and hence but one of these rods is necessary.

Fig. 2 shows one of these excavators, as worked by horse power. By means of hook-wrenches men may revolve the rods and do the boring. A, B, show clay-pipes; C is a wooden pipe; these are of little value where pressure has to be exerted in forcing the tube. Iron is generally used, as explained in a previous article. D is an extra shaft. Eight revolutions fill the auger. It is drawn up and emptied every two feet. The man at the crank feeds the auger and raises it when filled. In boring hard material the auger must be pressed down by some weight on the rods. When men are boring some of them frequently sit on the wrenches while others turn.

IMPROVED SAND AUGER.

Some kind of sand, gravel, and quicksand will not slide up into any kind of an auger over a foot deep, unless there is something to stir the sand and elevate it. Fig. 6 represents an improvement intended to manage such material. This auger has a spiral elevating core, an air passage down the center of the core, C (an inch in diameter), which prevents suction. The core is revolved and allowed to drop below the cylinder, A, far enough to fill. The cylinder does not revolve with the auger. When the auger-worm is full it is drawn up into the cylinder, and the sand, slush or gravel is held by the cylinder and leather flaps or valves, E, when all is drawn up together. The contents are discharged by sliding the cylinder up two feet. D is an adjustable set-screw and ring to regulate the sliding cylinder, A. The cylinder can be removed for clay boring.

None of these tools are adapted to boring in hard, solid rock. When this is encountered and must be bored through, other tools are needed, which we will now describe:

ROCK DRILLING TOOLS.

Fig. 8 represents a wedge bit. This bit weighs 100 pounds, and contains 40 pounds of English cast steel. When it is used, a reamer (Fig. 9) must be employed to keep the hole round and straight. A Z bit serves the purposes of both drill and reamer. Fig. 10 shows a sand pump.

Fig. 11 represents at work an improved well drilling and prospecting machine. The derrick ordinarily used is supplanted by a mast and frame, as shown. The drill is attached to a rope. A 1¼ inch hawser laid rope is used in boring to a depth of about 200 feet. Wire cable, ⅝ inch or ¾ inch, may be used for greater depths. The sand pump requires only ½ inch rope. The rope passes up from the hole over a pulley at the top of the mast, reaches down to and passes under the sheave on the inclined lever, shown as a diagonal of frame. From the sheave the rope passes under a roller at the foot of the mast, and then up over the large drum or rope spool. The revolution of this spool controls the lowering and raising of the drill. When the latter is to be lowered, the operator jerks the rope, which, in the figure, is shown as held in the right hand. The jerk pulls away the pawl from the ratchet wheel, and allows the latter to revolve as many notches as the operator wishes. This wheel in turn controls the spool, which unwinds the rope when the ratchet is free. The churning motion of the drill is given by the raising and lowering of the inclined lever. The lever acts exactly as a big treadle on a grindstone, for instance, the revolving arm taking the place of the foot of the grinder. To draw the drill up, remove the rope clamp the left hand is shown as holding, move a slide on the left side of the machine (not shown in the cut) with the foot, and the lever latch will hold the lever down. Then, with the left hand placed on the small lever (just below the elbow of the left arm), throw the clutch in gear, thus connecting the rope spool by cog wheels with the axle on which the revolving arm on the right turns. This axle, continuing to turn the spool or drum, winds up the rope. The sand pump rope is shown at the small pulley, half way up the mast. It passes down and is wound upon a reel, shown near the center of the frame. This reel is revolved by a friction belt, which is controlled by the treadle lever, shown near the left foot of the operator.

The power to run the whole machine is furnished by one or two horses. The horse power is connected with the machine by means of a tumbling rod, as shown. It is said that two horses and one man are all that are needed to do all the work; and the operator need not leave his seat, except to empty the sand pump, and to unscrew or to remove the drill bit, etc. These changes can be made without stopping the horses.

The portability of the machine is greatly added to by the hinge, shown about five feet up the mast, which allows of the latter's being folded down upon the frame.

DIRECTIONS FOR STARTING THE DRILL.

The following directions for using this machine contain much practical information applicable to boring with any apparatus. Start the drill slowly and carefully. A man or boy must stand at the drill to turn it around a little each time it is raised, so the drill will not strike twice in the same position. Before starting, be sure that the bit and rods are tightly screwed together by means of a wooden lever inserted between the handles of the wrenches. This is a very important point and should not be neglected. Drill with a tight rope; do not let out too fast, but drill on what is called "the spring of the rope;" otherwise, the hole will not be straight. Keep three feet of water in the hole, all the time, while drilling. In many cases, it is not necessary to pour water in the hole after sinking 20 or 30 feet, as some water is often found at that depth. As soon as the drill has worked down 20 or 24 inches, let the lever latch slip, which will stop and hold the main lever down, which stops the churning motion of the drill; then throw the clutch in gear and draw the drill out; then put in the sand pump and churn it up and down by hand four or six inches about 25 times, when it will be filed with the chippings of rocks, bear down on the friction belt lever and raise the sand pump out, empty it (see, each time, that the leather valve at bottom of sand pump is clear of all small pieces of rock or mud), repeat this operation five or six times or until all the hole is cleared of the chippings or other sediment, then lower the drill down to within 18 inches of the bottom of the hole. Push the lever latch back and drill down 20 inches farther as before. Don't stop until 10, 20, or 30 feet of water is found, or until it flows above the surface, if you want a flowing well. The drilling can be continued just as well, if there is 100 or 200 feet of water in the well.

Fig. 7 represents a drilling machine as used for sinking test holes for minerals, or for boring wells. As the large disk or wheel is rotated, the steel arm connecting i with the drill rod is carried upward. The arm in being raised clamps the drill rod, and carries the latter up with it. As the arm passes over the center of the disk, it turns the drill rod one-fifth of a revolution. When the arm is directly over the shaft on which the large disk revolves, the arm is released, and the drill rod and arm fall together. In falling, the arm ceases to clamp the rod, which falls freely, allowing the drill to strike a full blow. The drill can be made to strike 50 or 60 times per minute. The disk or wheel represented in the figure is 28 inches in diameter, and the slot made so that the drill is raised 14 inches every revolution. The drill is raised from a deep hole by placing the ring or arm, H, at the dotted line, to catch and hold the drill as it is being raised, by the same motion that is used in drilling. The poles of tripod should be 25 feet long, of common rough poles. They are used to rest the drill rods against after they are drawn up and unscrewed. This saves the trouble of laying them down on the ground and raising them up again. J is two gas pipe drill rods 15 feet long, screwed together in the middle. The screw couplings welded in each end are steel. I is a sand pump.

Fig. 1.

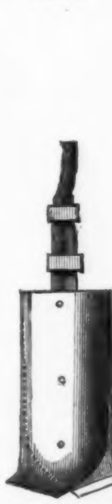


Fig. 2.

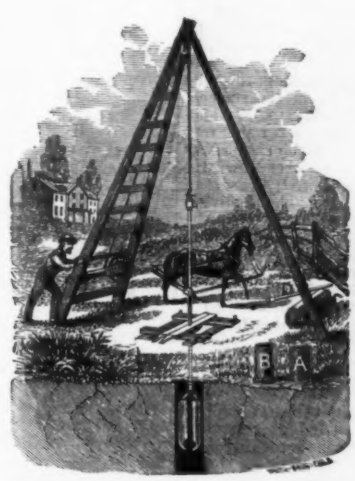
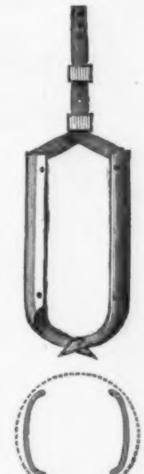


Fig. 3.



EXCAVATOR WORKED BY HORSE POWER.

RATE OF BORING.

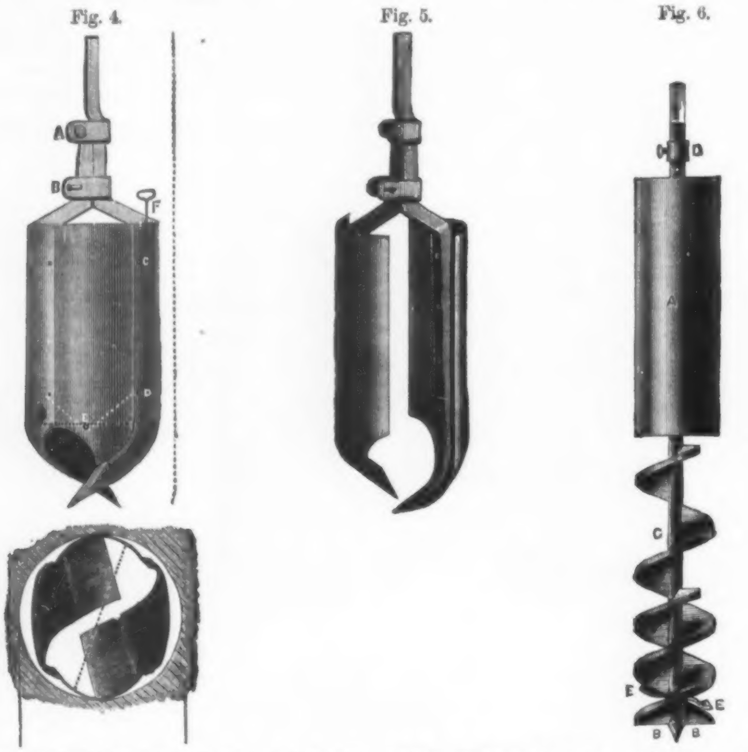
Under this head nothing can be better than to quote an extract made by Spon * from Andre:

"There are probably no engineering operations in which the rate of progress is so variable as it is in that of boring. That such must necessarily be the case, will be obvious when we bear in mind that the strata composing the earth's crust consists of very different materials; that these materials are mingled in very different proportions, and that they have in different parts been subjected to the action of very different agencies, operating with very different degrees of intensity. Hence it arises not only that some kinds of rock require a much longer time to bore through than others, but also that the length of time may change within a short horizontal distance. Thus it is utterly impossible to predicate concerning the length of time which a boring in an unknown

* "The Practice of Sinking and Boring Wells." Ernest Spon, London.

district may occupy, and only a rough approximation can be arrived at in the case of localities whose geological constitution has been generally determined. Such an approximation may, however, be attained to, and it is useful in estimating the probable cost; and to attain the same end, for unknown localities, an average may be taken of the time required in districts of a similar geological character. The following, which are given for this purpose, are the averages of a great number of borings, executed under various conditions by the ordinary methods. The progress indicated represents that made in one day of 11 hours.

Fig. 4. Fig. 5. Fig. 6.



EIGHTEEN-INCH EXCAVATOR AND IMPROVED SAND AUGER

1. Tertiary and cretaceous strata, to a depth of 100 yards, average progress 1 ft. 8 in.
2. Cretaceous strata, without flints, to a depth of 250 yards—2 ft. 1 in.
3. Cretaceous strata with flints, 250 yards—1 ft. 4 in.
4. New red sandstone, 250 yards—1 ft. 10 in.
5. New red sandstone, 500 yards—1 ft. 5 in.
6. Permian strata, 250 yards—2 ft.
7. Coal measures, 200 yards—2 ft. 3 in.
8. Coal measures, 400 yards—1 ft. 8 in.

General average, 275 yards; progress, 1 ft. 9 in.

Should hard limestone or igneous rock be met with, the rate of progress may be less than half the above general average."

THE EVANS WELL.

A new artesian well, lately completed in Stanislaus county, California, on the farm of Mrs. C. M. Evans, is one of the best in the San Joaquin valley. Depth of well, 310 ft. Strata as follows: Surface soil, 3 ft.; hard pan, 12 ft.; quicksand, with thin strata of clay running through it, 76 ft.; quicksand, 122 ft.; cobblestone, 20 ft.; heavy, coarse gravel, hard blue clay, 50 ft. After penetrating this the first flow was obtained, rising within 3 ft. of the surface. Sandstone, 1 ft.; quicksand, 22 ft.; white clay, under which was obtained the present flow, 4 ft. The bore of this well is 7 inches. After striking the first flow 6-inch casing was sunk, and below that point somewhere another flow was obtained, beyond which 5-inch casing was used; the second flow brought the water just above the top. The pipe rises above the surface 2 ft, and water comes up in a steady, rapid current 3½ inches above the edge of the pipe. Old miners estimate the stream at 22 inches, miners' measurement. Others estimate a flow of 175 gallons per minute, or 252,000 gallons per day. The area which it will irrigate is variously estimated at from 40 acres to 320 acres. This is purely guess work, as no one has data by which to determine; and the area irrigated by two wells of equal capacity will vary widely according to the locality and degree of heat, and consequent evaporation, and according to the different kinds of soil to be irrigated and the kind of vegetation raised upon it. Again, the amount of water required after the second year will be much less than that required the first two years, before the soil becomes thoroughly saturated. The land on Mrs. Evans' ranch is a light sand loam, heavier than the soil east of her, and lighter than that north and close to the San Joaquin river. Her well is 3½ miles north of Hill's Ferry, and one mile east of the river. The total cost of the well was $450.

DEEP ARTESIAN WELLS.

There are three conditions essential to the successful boring of an artesian well: 1, a fountain head more elevated than the locality where the boring is to be undertaken; 2, a moderate downward dip of the strata, toward the site of the well, as a steep angle is unfavorable and permits the water to flow away beyond the reach of the boring, which must needs pass at an acute angle through few layers of rock; 3, alternation of porous and impervious strata beneath the surface soil. It is sometimes the case that the head of water is at so high an elevation that the column bursts forth from the ground as a fountain, throwing up a continual jet. By raising the water above the surface in a pipe, and letting it flow over, convenient water power is obtained. Artesian wells are applied to this purpose at many localities in France, the water they supply being found sufficient to run heavy machinery. From the great depth at which the currents of water are reached, the supplies may be regarded as permanent. A well at Aire, in Artois (from which name the word "artesian" is derived), France, has flowed steadily for a century, the water rising above the surface at the rate of 200 gallons a minute; and at Lillers, in the same country, one well has given a constant yield since the year 1126.

As to the artesian well of Grenelle, a suburb of Paris, seven years and two months of constant labor were devoted to the boring, the rock being extremely difficult to pierce. The water-bearing stratum was reached at a depth of 1,802 ft., when the water was discharged at the rate of upwards of 880,000 gallons in 24 hours. The force is such that the water ascends to a height of 120 ft. above the surface, in the pipes in the elegant structure which has been erected over the bore. The present yield of the well is about 500,000 gallons in 24 hours. The water is at a uniform temperature of 82° Fah., and is used to warm some large hospitals in the vicinity. During the boring, and when at a depth of 1,254 ft., it is related that a drill broke and fell, with 270 ft. of rods, to the bottom, necessitating fifteen months of constant labor to remove the pieces.

FIG. 7.—MACHINE FOR BORING TEST HOLES.

In the United States the deepest artesian well is that bored for the insane asylum in St. Louis, Mo. This has reached the enormous depth of 3,843 ft., or, in that locality, 3,000 ft. below the sea level. This would give a water pressure at the bottom of 1,293 lbs. to the square inch.

The deepest bore in the world is one, begun as a rock salt mine and yet uncompleted, at the village of Sperenburg, some twenty miles from Berlin. Its present depth is 4,194 feet.

In the Desert of Sahara some seventy-five shafts have been sunk, which yield an aggregate of 600,000 gallons per hour. The effect of this supply is said to be plainly apparent upon the once barren soil of the desert. Two new villages have been built, and 150,000 palm trees have been planted in more than 1,000 new gardens.

Numerous artesian wells have been sunk along the line of the Union Pacific railroad, in order to obtain water for the locomotives and for the workmen laboring in the coal mines along the route. One well is at Separation, 724 miles from Omaha, and another one is at Rock Spring, 832 miles. It is believed that for agricultural purposes the mineral salts could be washed out of the water obtained from wells in the above vicinity, so that soil irrigated therewith would probably prove remarkably productive. A flowing well, furnishing 1,000 gallons per hour, will water a section of 640 acres. If bored 1,000 ft. in depth, the cost would be about $10,000. Out on the plains this outlay would make a most productive farm, which might be made the nucleus of a stock range of thousands of acres, having besides an ample supply for human consumption.

THE POTSDAM WELL.

The supply of water for Potsdam, a city of 50,000 inhabitants, near Berlin, Prussia, is obtained from artesian wells, pumped by steam, and distributed in 21 miles of iron pipes, under a pressure of about 50 lbs. to the square inch. The water is taken from fourteen tubular wells, about 30 ft. apart, in the following manner. A cast iron cylinder, 8 in. interior diameter, constructed of 6 ft. lengths, with ends turned to fit flush into one another and screwed together, was sunk in the usual manner to a depth of 40 ft.; a wrought iron 6 in. tube, put together in 6 ft. lengths, flush outside, was then sunk in the cast iron cylinder to a depth of 70 ft. to 75 ft., and the sand carefully cleared out. The permanent suction tube, 4 in. diameter, made of stout sheet copper with conical end, was then lowered and soldered together in lengths as convenient, 20 ft., till the lower end rested in the sand; the wrought iron tube was then withdrawn and the water pumped out by hand till it flowed clear. A copper hood or bend containing a clack valve was then bolted on, and a 4 in. sluice cock fixed in place, both of which are inclosed in a brick chamber deep enough to take in the top of the cast iron cylinder, the whole of which remains *in situ*, and covered in with frame and planks at finished surface level. The bottom length of the suction tube, 10 ft., with ½ in holes in rows ½ in. apart, between which thirteen vertical hollow ribs, ¼ in. high, are soldered on, so that in section this part of the tube resembles a toothed wheel. Three layers of brass wire gauze, about 1,200 meshes to the square inch, are wound over the ribs and soldered fast. The suction—or filter—area of each tube is thus about 11 square feet, and, as each tube yielded at a trial 6 liters per second, the yield per square foot per minute was about 7½ gallons. The water in the tubular wells, when at rest, stands 4 in. or 5 in. above the level of the river close at hand. The soil passed through consists of alluvium, running sand, a thin streak of clay, then better sand with fragments of lignite, another layer of clay, and, at 18 to 20 meters depth, good sharp sand and fine gravel.

At Prairie du Chien, Wisconsin, an artesian well, 960 ft. deep, was started in 1876, to discharge 869,616 gallons of water daily, with a force equal to a head of 900 ft.

At Her Majesty's dockyard, Chatham, England, a new artesian well lately reached a depth of 903 ft., and the water then overflowed the top of the well.

A HOT WATER WELL.

The city of Pesth, Hungary, has almost accomplished the task of obtaining an unlimited supply of nearly boiling water, which will be available for public and private use. The ready heated fluid is obtained from a deep artesian well, from which, when completed, the water will issue in a mighty fountain, to the height of nearly fifty ft. The Pesth well has already attained a depth of 3,120 ft. The water now issuing from the bowels of the earth, three fifths of a mile below the surface, has a temperature of 161° Fah., and the work will be prosecuted until a warmth of 178° Fah. is obtained. The meaning of these figures will be better understood when it is remembered that the temperature of a hot bath is 98°, while that of boiling water is 212°. The daily supply is already 175,000 gallons, a quantity which will be greatly increased at the enhanced depth. The work progresses at the rate of 50 ft. a month, and recent improvements in the mechanical appliances render possible a still more rapid rate of working. This remarkable undertaking is being carried on partly at the expense of the city and partly at the expense of the engineers, Messrs. Zsigmondy.

COST OF BORING ARTESIAN WELLS IN ROCK.

Mr. Clarence Delafield, C.E., of New York, gives the following as the approximate ordinary cost of boring artesian wells through the rock formations of New Jersey and Pennsylvania, with the diamond drills, the diameter of the well being six inches:

For the first 100 ft., $6 per foot	$600
" " second " " 7 " "	700
" " third " " 8 " "	800
For a well 300 ft. deep	$2,100

The cost may be estimated to increase $1 per ft. per each additional 100 ft. Thus the cost of a well 1,000 ft. deep, would be $7,000; add for contingencies, $3,000, and we have $10,000 as the total cost.

Fig. 8.—DRILL.

Fig. 9.—REAMER.

Fig. 10.—SAND PUMP.

Fig. 11.—IMPROVED WELL DRILLING AND PROSPECTING MACHINE.

THE UNITED STATES CAPITOL, WASHINGTON.

THE United States Capitol at Washington has a varied and not uninteresting history. In July, 1792, the task of building the Capitol was awarded to Stephen L. Hallett, by birth a Frenchman, whose design was successful in the competition instituted by Thomas Jefferson. On September 18, 1793, the corner-stone was laid by George Washington. Hallett was the object of much jealousy, and was, during his short term of office, which lasted only until July 1, 1794, engaged in a struggle with a would-be usurper of his position, one Dr. William Thornton, an amateur. It was not until 1871 that Hallett's claim to be considered the first architect of the Capitol was finally allowed and his designs restored to their proper place in the archives. The next architect in charge was George Hadfield, an Englishman, who carried on the work until he was driven from office, in 1798, by the same treatment that had banished his predecessor. James Hoban, an Irishman, next succeeded to the office, and under his administration the north wing was finished in 1800. In 1803, Hoban was succeeded by Benjamin H. Latrobe, an Englishman, who continued in office until 1817. During this period the south wing was finished, and both wings, which, on August 24, 1814, had been partially destroyed by fire set by the British troops then holding the city, were rebuilt. In 1818 the central portion of the building was begun under the direction of Charles Bulfinch, who finished the original building in 1827, at a total cost of $2,433,844.13. The necessity of providing further accommodations for the ever-increasing body of government officials had become so apparent in 1850, that a competition was held which resulted in the award of the premium of $500 to Charles F. Anderson, an Irishman. His design was not, however, carried into execution, as the government had reserved the right to build in accordance with the accepted design, or adopt a new plan which should combine the good points of the several designs submitted. This last course was followed; Mr. Thomas U. Walter, of Philadelphia, now president of the American Institute of Architects, was appointed architect of the Capitol extensions, and remained in office until they were virtually completed. Since that time the building has been under the charge of Mr. Edward Clark, who is the present incumbent of the office. Work on the extensions was begun by laying the corner-stone July 4, 1851, and was finished in 1867. The original building, the present main building, was built of a porous sandstone, obtained from Aquia Creek, Va., which is painted white so that it may harmonize, as far as possible, with the new portions, that are faced with white marble obtained from Lee, Mass. The wooden dome of the original building was taken down in 1856 to give place to the present iron dome, which is said to contain 8,909,200 pounds of iron. This dome, unquestionably one of the great achievements of architecture in this country, was finished in 1865. It is surmounted by a bronze statue of Freedom which was modeled by Crawford. The figure is nineteen and one half feet high, and weighs 14,985 pounds. The apex of the dome is 288 feet above the base line of the east front, and is therefore a less lofty dome than St. Paul's at London. Its height above the balustrade of the main building is 217 feet; its greatest diameter is 135 feet 5 inches. It surmounts the circular entrance-hall known as the Rotunda, which is 95 feet 6 inches in diameter. The interior of the dome is at present being decorated in true fresco by the veteran artist, Brumidi. The greatest length of the building, which is said to have cost more than thirteen millions of dollars, is 751 feet, and the greatest width is 324 feet, including steps and porticoes. The wings of the building, which are commonly known as the "extensions," are placed at the north and south ends of the building, and contain respectively the Hall of Representatives and the Senate Chamber, which are of nearly similar size, and in spaciousness offer a marked contrast to the somewhat gloomy and cramped chambers in which sit the houses of the English Parliament. The semicircular hall on the left of the main building is the old Hall of Representatives, now the National Statuary Hall, or Hall of Heroes, in which each State of the Union is to be represented by statues of two of its most noted citizens. Here Rhode Island will be represented by General Greene and Roger Williams; New York by George Clinton and Robert R. Livingston; New Jersey by General Kearny and Richard Stockton; Massachusetts by Governor Winslow and Samuel Adams; Connecticut by Jonathan Trumbull and Roger Sherman; Maryland by Charles Carroll and Roger B. Taney; and Pennsylvania by Robert Fulton and General Muhlenberg. The library, on the west of the main building, was burned by the British in 1814, and was again partially destroyed by an accidental fire in 1851, when 35,000 volumes were burned.—*Amer. Architect.*

THE FAILURE OF CONCRETE AT CAMBRIDGE.

THE failure of concrete floors in the New Comparative Anatomical Schools at Cambridge, Eng., which occurred in February last, forms the subject of a special report, by the Museums and Lecture-rooms Syndicate to the Senate of Cambridge University, in which all the circumstances and subsequent correspondence are set forth in detail. Although the building itself was a comparatively small one, the correspondence is instructive as showing the incapacity of concrete to resist tensile strains, although it behaves admirably under compression. It is exclaimed that the school buildings were designed by Mr. W. M. Fawcett, and were erected under his superintendence in two contracts by Messrs Bell. When nearly completed on Feb. 18 last, a slab of concrete forming the northernmost compartment of the roof gave way and fell to the ground, carrying the floor with it, and three men at work on it. The syndicate on the following day instructed Messrs. Arthur W. Blomfield, M.A., and Thomas M. Rickman to examine and test the soundness and stability of the concrete floors throughout the building. In their report they state that the structure was three stories in height, and about 40 ft. from the ground to the parapet, and having a basement under part of building. The external walls, which varied from 2½ bricks to 2 bricks in thickness, were of ample strength. The floors and roof throughout were constructed of concrete of an even thickness of 6 in., and excepting the roof perfectly level. The passages, landings, and roof were finished with cement paving, making a total thickness of 7 in. The floors were carried on rolled iron joists of the following weights and sizes:—18 ft., bearing 9¼ in. deep, 25 lbs. per foot run; 20 ft., bearing 10 in. deep, 33 lbs. per foot run; 24 ft., bearing 12 in. deep, 43 lbs. per foot run. The concrete floor was carried down from the top of the girder to the bottom flange by a filling-in finished with a slope, and at the top of each girder was a joint between the several slabs of concrete. This concrete was filled in over boarding, which formed a level center for it, and which was originally set with a camber of ⅜ in., which was brought down to a level line by the weight of the concrete before it set. The concrete was made with six parts of clean-washed shingle passed through a 1 in. gauge, and one part of clean-washed sand, and one part of the best Portland cement, with sufficient water thoroughly to set in one hard mass, and was fully up to this standard. The accident seemed to have been caused by jarring in lifting a coping-stone, and involved the fall of a whole compartment of concrete, 18 ft. by 11 ft., and the destruction of each of the floors on which the masses fell. The report adds that the concrete in the floors was very hard, although it did not contain so much sand as might have been used. The roofing material was, however, decidedly inferior, and no floors could be expected to withstand the fall of 4 or 5 tons of material. A portion of one of the girders, 7½ ft. long, was subsequently tested by Mr. Kirkaldy, of Southwark, and found to be more brittle than could be wished for. It bore a load of 19½ tons without deflection, but broke under 35 tons, and proved to be crystalline instead of fibrous in texture. Messrs Blomfield and Rickman, therefore, considered that the joists were not of sufficient strength for the purpose, and that the floors were so designed that any use to which they might be put trenched in many instances seriously on the working margin left in the calculations. Mr. Fawcett demurred to some of the conclusions in their last report, and to the proposed strengthening of the girders, and was permitted to test, with Mr. Mullett, two of the existing floors. They bore, the one a strain equivalent to 2 cwt. per super. foot, with $\frac{1}{12}$ in. temporary deflection, and the other nearly 3 cwt. with $\frac{1}{16}$ in. deflection. Mr. Baldwin Latham, C.E., was consulted by Mr. Fawcett, and pronounced the cause of failure and settlement in the concrete floors to be due to inherent defects in the material when applied to a large building liable to settlement from compression of the foundation, or from settlement in the walls. Concrete, he remarks, is often liable to fall from a simple jar, owing to the drying of the outer faces before the interior has set from crystallization. As the material will resist a very great compressive strain, but cannot withstand a tensile strain, it ought not to be used in large slabs. The girders in this particular building were insufficient, and should be strengthened throughout the building. Plans were then prepared by Mr. Fawcett, in consultation with Mr. Latham, providing for the reconstruction of the faulty compartments of roofs and floors, and for the strengthening of the rest by additional girders and columns, and were approved by Messrs Blomfield and Rickman. The syndicate, however, were not altogether satisfied with the new plans, and it was eventually decided, on the advice of Mr. Latham, to remove the whole of the concrete roof and replace it by one of wood, slated; to reconstruct certain bays of the floors—these, as well as those which have fallen, to be of wood in place of concrete, and to strengthen the other floors with additional ironwork. These works were undertaken at once; but, owing to the sagging and cracking of some of the old floors during the work, Mr. Latham was again consulted, and it was determined to remove the whole of the concrete floors except that on the ground level, and replace them by wood. The question of the respective liabilities of Mr. Fawcett and the University for the cost of these works of reconstruction has been referred to the arbitration of Mr. Chas. Barry, P.R.I.B.A., who has taken evidence and inspected the building, but has not yet made his award.—*Building News.*

A NEW LIGHTSHIP.

A NEW iron lightship has been stationed by the Lynn Harbor and Dock Trustees at the entrance of the channel, near the Wisbeach Bay buoy. The lighting apparatus consists of three large dioptric lanterns, on a triangular frame, the three lights blending into one at a moderate distance from the ship, and visible within a radius of seven nautical miles.

HOT AND COLD WATER PLUMBING.

TAKING the simplest case of supply by a service pipe brought into the cellar from the street main, we have the choice of two modes of distributing the water over the house: either the pipe can be carried up through the house, throwing off branches on the way to all the cold-water cocks, and terminating at the highest faucet; or from the street supply a single pipe may ascend to the highest part of the house and empty into a tank, with a ball-cock to shut off the supply when full, and from this tank will descend the pipes, one or more in number, which, ramifying downward, simply supply the different faucets.

Where the water is obtained from a water-ram, or a force-pump drawing from a well or cistern, or by rain-water received directly from the roof, the second method, employing the tank in the attic with downward supply, is necessarily adopted. When it can be used, however, the first method is the cheapest, as it saves one pipe the height of the house and the cost of the tank, besides certain pipes hereafter described; but it has certain disadvantages. Besides the obvious risk of having the house left without water in case the supply is shut off while repairs are making, the street pressure is often very heavy, reaching in some localities one hundred or even one hundred and fifty pounds per square inch, and the consequent strain upon pipes and fittings is very severe. Moreover, the head in the mains is sometimes variable, and this irregularity interferes with the working of valves and faucets.

With the tank system the pressure in all but the rising main is constant, and can never exceed the head due to the height of the tank above any given faucet, not over twenty-five pounds in the highest house; all the apparatus is therefore under the most favorable conditions for perfect working and long service. It should not be forgotten that in a pipe under heavy pressure the shock caused by suddenly shutting a faucet is equal to the blow of a hammer of weight equivalent to the pressure, say one hundred pounds, striking with a velocity equal to that of the stream of water at the moment when it is arrested; and this blow is applied just as much on every square inch of surface in the pipe as at the faucet. The weakest part of the pipe, usually at a bend or near some joint, soon yields a little, and the effect of the blows increasing as the resistance diminishes, an opening is finally made. Even brass pipe, whose elasticity enables it to recover from repeated strains, often gives way at last.

But the worst deficiencies of the direct pressure system are to be found in the hot-water service. To understand this clearly requires a little consideration of the construction and working of the bath boiler and water-front.

THE WATER-HEATER.

The water-front is a closed box of cast iron, which occupies one side or corner of the range, next to the fire. In the outer side are two brass couplings, one near the top and the other near the bottom, extending through to the outside of the range. Sometimes the place of the water-front is supplied by a copper tube, which starts from one coupling, and after traversing the fire two or three times ends at the other coupling; but these tubes are apt to boil the water in them with violence, and if the water is shut out of them they get red-hot and burn out, so that the iron front is to be preferred.

THE BOILER.

The boiler, which usually stands beside the range, is simply a cylinder of stout sheet copper, tinned inside, with a flat or slightly convex bottom, and in all but the poorest specimens a dome-shaped top. One or more galvanized iron bands are fixed in the interior to strengthen it, and two, three, or four couplings are attached to the head, one in the side about eighteen inches from the bottom, and one either in the bottom or very low down in the side. The two lower couplings are connected by brass tubes with those of the water-front, and either on the lower tube or with a separate connection is a "sediment cock" for emptying the boiler and water-front. From one of the couplings in the head of the boiler a copper tube extends down to within six inches or so of the bottom, with open mouth, and near the top of this tube a small hole is bored. To this coupling is attached the pipe for cold-water supply. The cold water from the pipe descends through the tube, and accumulating naturally in the lower part of the boiler, passes through the lower coupling and the connecting brass pipe into the water-front of the range. Here it is heated, and, becoming lighter as its temperature rises, it ascends and passes through the upper coupling of the water-front, up the second pipe, which, to facilitate the movement, is laid with a gentle ascent toward the boiler, and, entering through the side coupling, takes its place in the upper portion of the boiler. This circulation constantly goes on between the water-front and boiler, and the water passing repeatedly through the range becomes warmed in proportion to the ratio which the heating surface of the water-front bears to the cooling capacity of the boiler. The difference in temperature between the upper and lower portions of the boiler and the upper and lower connecting pipes to the water-front may be plainly felt with the hand.

The other couplings in the head of the boiler simply communicate with the inside, and to them are attached the pipes which supply hot water to the house. Several couplings are used where the number of sinks and wash-bowls to be supplied is considerable, to obtain a freer flow than could be obtained from a single pipe compelled to supply several faucets; but one pipe is sufficient for a small house.

OPERATION OF THE SYSTEM.

When a cock anywhere on this pipe is opened, the warm water issues under the same pressure as that of the cold water; for the whole system of pipes and boiler being constantly full of water, the pressure is the same throughout at the same level, the boiler being practically nothing but an enlargement of the supply-pipe, while the water-front, with its tubes, represents a loop through which portions of water are continually drawn from the boiler to the fire, heated and returned.

The drawing of hot water in any part of the house subtracts from that in the top of the boiler, causing an equivalent amount of fresh water to enter through the cold pipe, from which it is led without mixing with the warm upper stratum through the copper tube to the lower or cool part of the boiler, there to begin its journeys through the water-front, by which it is qualified in its turn to take its place in the warm, upper region. This is the principle of the modern hot-water supply in its simplest application.

Under this system it is evident that the only circulation is between the water-front and the boiler, and that in the hot supply-pipe, each branch of which terminates at some faucet, the water remains stagnant except when a cock is opened, and loses its heat by radiation, so that on drawing from any faucet this stagnant, lukewarm portion must first run off before obtaining the hot water from the boiler itself. To remedy this it is customary not to terminate the warm-water pipes anywhere, but to make them constantly ascend through perhaps devious courses from one faucet to another, until they reach the highest faucet, from which a pipe descends again and returns into the boiler, sometimes by entering the cold supply just above the coupling, sometimes through the lower tube to the water-front, or by a coupling of its own near the bottom of the boiler. In this way a secondary though extensive circulation is set up through the pipes themselves, hot water ascending on one side and descending on the other by virtue of the increase of its specific gravity on cooling; and at any point on the line water may be drawn of the same temperature as that in the upper part of the boiler, minus the comparatively small loss which it suffers in its rapid course from the boiler to the point at which it is drawn. To obtain this regular circulation in the hot pipes is essential to their satisfactory working; but it cannot always be managed unless the architect has kept well in mind the course of the pipes in arranging the wash-bowls and sinks.

DANGERS, ACCIDENTS, AND DEFECTS.

So far the system is the same, whether the boiler is supplied under the street pressure by a pipe connected with the main, or from a tank. But certain circumstances may interfere with the working of the apparatus. It often happens that the water-front is too large for the work it has to do, or the copper tubes which serve as a substitute are too much heated by a brisk fire, and the circulation not being rapid enough to keep down the temperature the water begins to boil, and bubbles of steam run through the upper tube toward the boiler. The mass of water in the boiler being still below ebullition point, the steam is condensed on reaching it, and the sudden reduction of a pipeful of steam to a drop of water leaves a vacuum which is instantaneously filled with water. The next bubble of steam meets with the same fate, and the successive shocks caused by the sudden rush of water into the vacuum cause a snapping and rumbling in the pipes and boiler which often alarm housekeepers.

If the heat should be so great as to bring the water in the boiler itself by degrees to 212°, the same phenomenon is in danger of being repeated on a larger scale. If all the faucets or other outlets are closed the steam accumulates in the pipes and the top of the boiler, and acquiring a tension superior to the pressure of the cold water forces it back into the main. The water in the main serves as an elastic safety-valve, so that the steam pressure will never much exceed that of the water, so long as the connection between the boiler and the cold supply is unobstructed, and if the boiler is strong enough to resist the water pressure there is little or no danger of its being burst outward by the steam; but there is a very serious risk that when the boiler is very hot and partly full of steam some one, by opening a hot-water faucet anywhere in the house, may allow a little steam to escape, and the tension being thereby reduced for an instant, cold water presses in from the supply. The admixture of the smallest quantity of fresh water lowers the temperature of the contents of the boiler and condenses the steam with increasing rapidity as more cold water rushes in to fill the void so made. This process goes on with extreme rapidity, so that in a fraction of a second after the cock is opened the steam has vanished, and the condensation being much more rapid than the entrance of the fresh water, a vacuum is caused in the upper part of the boiler, and the atmospheric pressure thus suddenly brought upon it crushes the cylinder like a leaf. This "collapse," as the plumbers call it, is a very common occurrence, and with a boiler supplied from the street pressure there is no sure way of preventing it. One or more vacuum valves are often inserted in the head of the boiler to open by the pressure of air from without; but these get so firmly pushed into their seats by the ordinary water pressure in the boiler that they are very apt to stick when most needed, and are then useless. Sometimes a stop-valve is put on the supply, intended to prevent the steam from pushing back the water; but this simply gives a closed boiler, sure to blow up if the steam pressure should exceed a certain limit. The only palliative, where the supply is direct from the main, is to be careful when there is a hot fire in the range to open the warm-water cocks cautiously, and if steam should come out to shut off instantly all but a small opening, which may relieve the pressure so gradually as to prevent harm. Compression cocks, which open by a screw, are for this reason safest in use; but it is essential also that the heating surface should be properly proportioned, and the pipes between boiler and range, as well as the circulation pipes, should be large and smoothly graded, and the flow therefore easy and rapid, to obtain even a moderate degree of security.

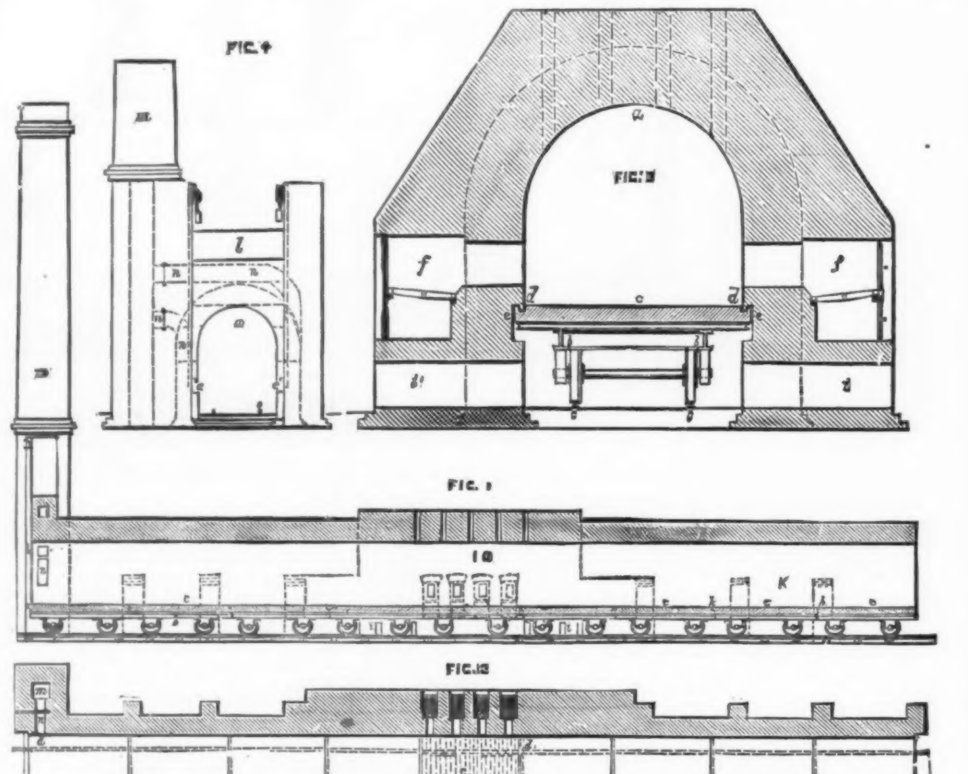
HOW SAFETY MAY BE SECURED.

Where the boiler is supplied from a tank the danger of collapse is almost entirely removed by the simple expedient of carrying up from the highest part of the hot-water system a one-half or three-fourths inch pipe above the water-level of the tank, leaving the end open, so that any steam which may be generated escapes quietly, without ever accumulating tension enough to force water out of the boiler. Unless this pipe should be so long and tortuous as to get choked it is a sure protection. The end of the expansion pipe is turned over the tank, or, better, over the mouth of the standing waste, so that the foaming mixture of water and steam which sometimes comes up may run off without doing mischief. Of course no such protecting pipe is possible under the pressure system.

The hot-water supply is sometimes arranged without a boiler by employing two tanks, one for cold and the other for hot water, both placed at the same level in the attic. The supply pipe descends from the cold tank to the water-front, and from the upper coupling of this a pipe ascends to the hot tank, from which a descending main branches to the different faucets. Both cisterns are open to the air, so vacuum or bursting pressure are there impossible; but an expansion pipe must be carried up from near the water-front to obtain complete security. This system is more expensive than that which employs the copper boiler, and the steam from the hot tank is disagreeable and injurious in the rooms, so that it is rapidly becoming obsolete.

Boilers supplied from the street pressure sometimes give way under the strain of the water alone, especially if they have been previously weakened by an incipient collapse, and where the head is considerable they must be of galvanized iron, riveted like a steam boiler.

Accidents also sometimes occur from attempting to empty the boiler, by the sediment cock without opening a faucet above to admit air, or in occasional instances, where the supply from the street has been connected at the bottom of the boiler by the retreat of the water in the mains, which, drawing with it the contents of the boiler, leaves a vacuum behind by which the cylinder is collapsed as effectually as by the sudden condensation of steam. The tank supply with the expansion pipe provides against this danger as well as the other.—*American Architect.*



THE FOSTER BRICK KILN.

THE FOSTER BRICK KILN.

THIS kiln consists of one long parallel chamber, *a*, into which the bricks are passed on iron wagons having fire-clay tops, *c*; these wagons are constructed to fit the sides of the kiln, as at *d e*, so as to be as air-tight as practicable up each side. When in operation, the burning part occupies by preference the center of the kiln, the fires being stationary in the sides of the kiln at *f*, as shown in Figs. 2 and 3, fuel being fed in from the top. A progressive motion is given as required to the wagons containing the bricks, from some suitable motive power. The chamber may be of any required length to contain a convenient number of loaded wagons at one time. As the bricks on each wagon are burnt

sufficiently, the latter is pushed or pulled forward, and another wagon containing unburnt forms takes its place at the burning part of the kiln. As each wagon is admitted at one end of the kiln, another containing burnt forms is simultaneously passed out at the other. The economy in fuel is obtained by placing the fires in one part only of the kiln, which is kept at an intense heat, instead of distributing them as usual. The cool air on its way to the fire passes into the kiln through the outlet for wagons, where it is heated by the burnt bricks, which are themselves gradually cooled. The inlet end for unburnt forms acts as the flue for the heated gases, from whence these pass to the chimney, *m*, by flues, *n*. By this arrangement the unburnt forms are gradually heated before being submitted to the intense heat of the firing part of the kiln. When the wagons are drawn from the kiln they may be taken to any convenient place for unloading.

In our illustrations, Fig. 1 is a longitudinal elevation, Fig. 2 is a sectional plan on the level of the furnaces, and Fig. 3, a sectional plan on an enlarged scale through C D, Fig. 1. Fig. 1 is a longitudinal section through the center of the kiln, Fig. 3 is an enlarged transverse section through E F of Fig. 1, and Fig. 4 is an end elevation, showing the balanced lifting door, *l*. It will be seen that a great saving of labor is effected by the kiln, and almost all the heat is utilized by the arrangement adopted of heating the air for combustion by the cooling burnt bricks and by passing the heated gases through the mass of unburnt bricks. Bricks may be sent into it with less preparation than for the ordinary kiln. The bricks after leaving the brick making machine are only once touched by hand until loaded into vehicles for consumers, and burning is effected, it is said, at a cost of 3d. per thousand.—*Engineer.*

CORNER MOUNT OF BOOK-COVER.

OUR engraving represents a corner mount of book-cover from the Royal Library in Munich. Date 1566. From a drawing of Prof. Dr. Stockbauer in Nuremberg.

This mount is authenticated as the work of goldsmith Jœrg, known by the name of Zeggein, as a native of the town of Szegedin, who worked for the Ducal Court of Munich from 1560-1593.

The book, Penitential Psalms by Orlando di Lasso, is bound in crimson leather, the four corners being mounted by the richly enameled ornament with boldly protecting lion's head, represented in our engraving. The lateral surfaces of the mount, decorated with translucid enamel, fold upon the thick wood cover, and are therefore not visible on the top.

In the center of the book-cover is the coat of arms of the Dukes of Bavaria.

The excellent effect of these elegant mounts is owing principally to the rich and harmonious treatment of color and material: The three heads, the pomegranates and other fruit on both sides are gold, leaves of wreath green with red reverse, all the diagonally-shaded parts are likewise green, the horizontal shading representing a warm deep blue, the dotting light violet; the contours of scrolls and volutes are white, in some parts light-red. The lateral ornaments show blue stones mounted in gold, the festoons are green, the ribbons violet, the lineal ornament scarlet, the central pendant gold, ground white.—*The Workshop.*

ON BLUE ALIZARINE.

By MM. H. KOECH and M. PRUD'HOMME.

THIS new coloring matter is offered for sale by the Alizarine Works of Ludwigshafen in the form of a brownish violet paste, containing 10 per cent. of actual coloring matter. Certain samples are blue. This substance contains nitrogen, which approximates it to indigo; indeed, its properties are intermediate between those of indigo and alizarine.

With concentrated sulphuric acid it forms a fine red solution; if heated for a certain time and then treated with water it deposits a blue precipitate, the tinctorial characters of which do not greatly differ from those of the original compound. Arsenic acid at 70° B. dissolves alizarine blue very easily. This solution is of an orange red, and, on the addition of glycerine, turns to a magenta shade. If the mixture of these three substances, however, is heated, and then mixed with water, the coloring matter is reproduced in the form of blue flocks. It takes the same appearance if it is stripped from goods dyed with it by means of dilute muriatic or sulphuric acid at a boil.

With lime, baryta, and strontia it gives bluish-green lakes. The alkaline salts, in general, form with blue alizarine lakes more or less insoluble.

A boiling solution of alum, or of sulphate of alumina, does not dissolve even a trace of this color, a characteristic which separates it distinctly from alizarine, purpurine, and their isomers.

In dyeing, the following shades are obtained with mordants:

Alumina	Violet blue.
Iron	Greenish blue.
Chrome	Violet.
Tin	Reddish violet.

Goods mordanted with nickel, according to the researches of M. E. Dolfus, are dyed a blue much purer than if prepared with any other mordant.

The coloring matter being but slightly soluble in water, a small quantity of soap is added to the dye-beck, or, preferably, sulpholeic or sulphoricinic acid, with a slight excess of ammonia. The proper proportions are one part of blue alizarine at 10 per cent., and 1 to 2 parts of fatty acids. The flot is heated to 158° Fahr., at which temperature the color is dissolved by the aid of the fatty acid and the ammonia. It is then raised to a boil in the course of an hour, and kept at that heat for half an hour. The presence of certain alkaline salts, such as phosphate of soda, favors the operation of dyeing. Chalk is not objectionable, but it is not the same with caustic lime, which converts the color into an insoluble lake. The whites are but little soiled during the dyeing, and merely require a soaping at 122° to 140° Fahr.

Blue alizarine may also be used to dye cloth after the manner of indigo. It possesses, in fact, the curious property of becoming reduced in alkaline solutions, yielding a red vat with a blue froth. Taking advantage of its sparing solubility in water, and of its disposition to form lakes with lime, it has been found practicable to dye cottons with a vat of blue alizarine, set either with zinc and soda, or with hydrosulphite of soda. The cloth, saturated with the reduced solution, is exposed to the air; when the reoxidation is considered sufficient, it is taken through cold chloride of lime—or better, bichromate of potash—mixed with more or less lime water. This dyeing is not effected by mere imbibition, followed by subsequent reoxidation. The attraction of the fiber, well known in the case of indigo, exists also for blue alizarine. It is easy to prove it by dyeing swatches for different lengths of time, and showing that the depth of the shade increases with the duration of the dyeing.

The reduced solution of alizarine blue may also be applied in printing. The following color gives good results, at least as far as brightness of tone is concerned, for the resistance to soap and to light is not quite satisfactory:

Blue alizarine at 10 per cent.	$8\frac{3}{4}$	fluid ounces.
Gum water at 10 lbs. per gallon	$26\frac{1}{4}$	"
Glycerine at 28° Baumé	$2\frac{1}{4}$	"
Caustic soda at 36° B.	$2\frac{1}{4}$	"
Zinc powder	$\frac{3}{4}$	ounce.

The deficient solidity of this color depends on the absence of any mordant properly so called. If chrome or iron is introduced in the form of salts not capable of being precipitated by alkalies, better results are obtained. Blue alizarine, reduced with stannate of soda, and thickened with dextrine, gives, on steaming, a violet which bears soaping well. This color may be also fixed upon cloth by a procedure analogous to that of China blue, that is to say, printing it on suitably thickened, and taking it alternately through a reducing or an alkaline bath.

The greatest interest presented by blue alizarine centers in its easy application upon cloth by means of steaming, which (disregarding its present high price, 10 francs per 2 lbs. 3 ozs. at 10 per cent.=3s. $9\frac{1}{4}$d. per lb.) places it above ultramarine and steam indigo.

The best fixing agents for this dye are yellow prussiate and acetate of chrome, which give solid shades, but with a slightly violet cast. The addition of acetate of lime to the color to counteract this tendency is not advantageous. The shade produced is of a purer blue, but deficient in brightness. M. Depuy employs acetate of chrome conjointly with

SUGGESTIONS IN DECORATIVE ART—CORNER MOUNT OF BOOK COVER.

chloride of calcium. The authors use instead of the latter body chloride of magnesium, and make up a color as follows:

Thickening	5 lbs.	7¼ ozs.
Blue alizarine at 10 per cent		17¼ "
Acetate of chrome solution at 10 per cent		5½ "
Chloride of magnesium, same strength		5½ "
Yellow prussiate ditto		2¾ "
Glycerin		11 "
Thickening:		
Water	6 lbs.	9 ozs.
White starch		4¼ "
Light calcined starch		13 "
Olive oil		5¼ "

The addition of acetic acid to the color by way of solvent is not advantageous. The shades produced are paler and grayer.

This color is printed upon cloth prepared with a fatty acid, an essential condition for success. About one part of sulpholeic acid should be used with 20 to 30 parts of water.

Steam one and a half to two hours. Wash and soap 20 minutes at 122° F. Take through boiling lime water 15 grains of quicklime per 35 fluid ounces of water. This gives a greenish blue shade, owing to the formation of a lime lake.

Wash well and soap at a boil, which restores the blue to its original purity.

Baryta and strontia produce upon blue alizarine an effect similar to that of lime. Dilute soda and potash turn the violet shade to a decided blue. Certain oxides almost insoluble, such as magnesia and oxide of zinc, act in a permanent manner upon alizarine blue when already fixed so as to modify its tone.

The alizarine blue fixed by our process bears chloride of lime and light. It turns certainly more gray on exposure to the sun, but its fastness is comparable to that of a vat blue. —*Bulletin de la Société Industrielle de Mulhouse.*

HOW TO MAKE AN INDUCTION COIL.

By GEO. M. HOPKINS.

FARADAY discovered in 1832 that a galvanic current was capable of inducing other currents in wires near but not in contact with the conductor of the primary galvanic current; these he named *currents of induction*, or *induced currents*.

Since the discovery of Faraday, the phenomena of induction have been exhibited by many forms of apparatus; but the most striking example of inductive action is afforded by the induction coil. Prominent among makers of this instrument are Ritchie, Ruhmkorff, and Ladd. The performance of the induction coil is familiar to many of the readers of this journal; but its construction is not so well understood.

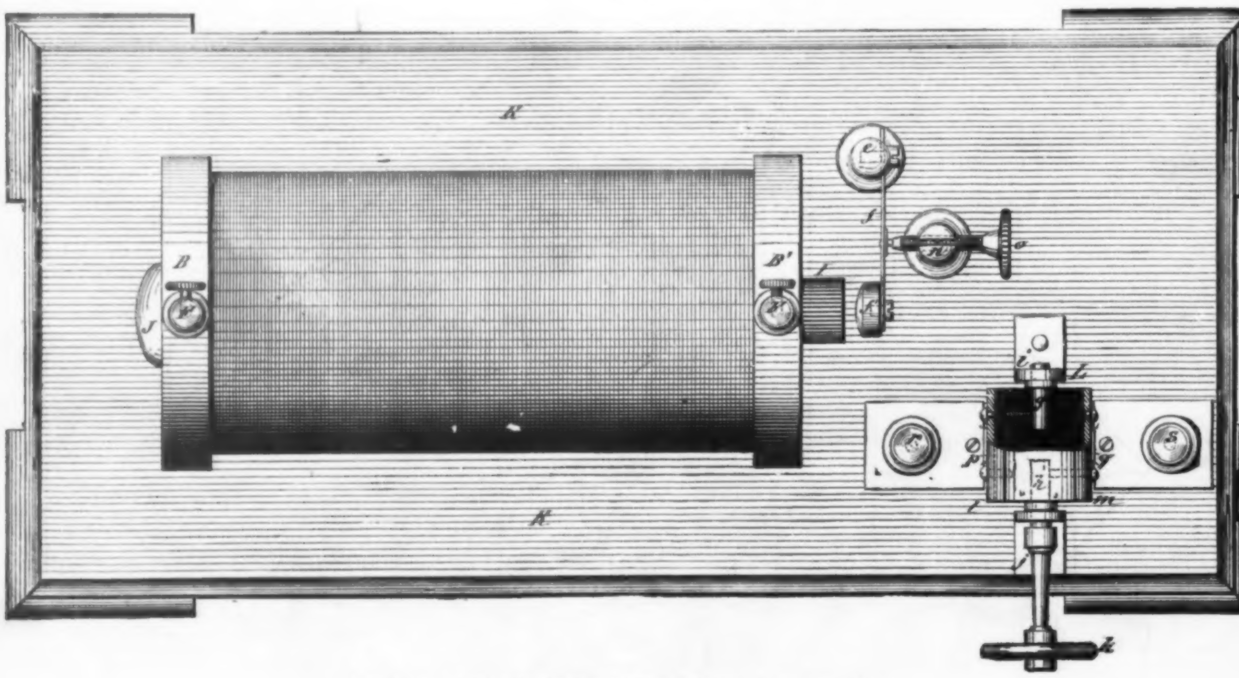
There are two methods of making an induction coil; the simpler, cheaper, and perhaps the best will be described in connection with the accompanying engravings, which, with the exception of figure 4, are exactly one half size, and may be used as working drawings from which to construct the instrument. Figure 1 is a plan view. Figure 2 is a central, vertical longitudinal section. Figure 3 is a vertical transverse section, taken through the coil, near one end, and looking toward the commutator. Figure 4 represents the under side of the base, in plan, and the condenser, in perspective, and shows the connections.

The coil consists of two portions, the inner or primary, and the outer or secondary. The primary coil, C, consists of two layers of No. 16 cotton covered copper wire, which is wound upon a spool composed of the thin paper or wooden tube, A, and the heads, BB, which are of vulcanite, or well varnished hard wood. The tube is ⅞ inch internal diameter, and the heads have each a central hole of the same size. These holes are enlarged or counterbored to receive the ends of the tube, A, which are glued or cemented therein. In the head, B′, there are two small holes near the large central hole, for the terminals, *c d*, of the primary coil. One of these terminals is put through the head before the winding operation is begun; the other, after the winding is finished.

The primary coil must now receive four coats of moderately thick alcoholic shellac varnish; each coat being allowed to become dry before another is applied. When the primary coil has become thoroughly dry and hard, it is covered with three or four layers, D, of stout cartridge paper, which is fastened by a little gum along its outer edge. This paper covering must fit between the heads, BB′, perfectly, and must be well smoothed and rounded, and varnished with shellac, taking care to cover the joints at the ends, and also to varnish the inner faces of the heads. The secondary coil, E, is wound in two sections separated by an insulating medium, G, which is applied in the manner presently to be described. The coil, E, is of No. 36 naked copper wire; the two sections being connected at H.

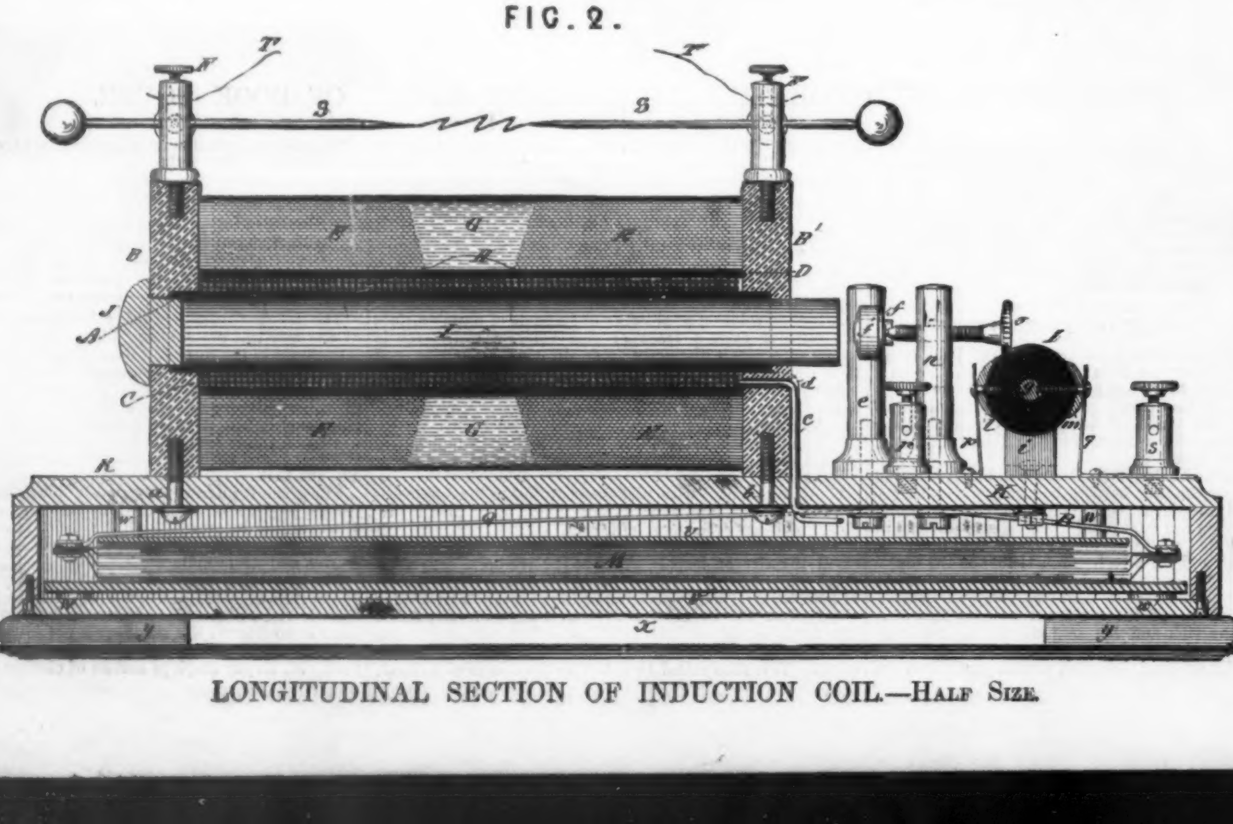
The winding is best done in an engine lathe, the wire being allowed to pass through a fine guide in the tool post, and the screw cutting gear of the lathe being set as for cutting a very fine thread. The different convolutions of the wire should be as near together as possible without touching. To accomplish the same thing in an ordinary foot lathe, a piece of quite thin brass should be bent together in a U form, and the wire should be allowed to pass through the channel thus formed; the thickness of the metal will regulate the space between the adjacent coils of wire. The winding begins at the middle, leaving the terminal, H. When one of the heads is reached, the coil or layer formed is covered with three thicknesses of common white tea paper or quite thin writing paper, the edge of which is fastened with a little gum. The winding of the fine wire is now continued toward the center of the coil; when the second layer is complete, it is covered as in the case of the first coil, when the third is wound on, and so on until it is about 3⅜ inches in diameter. The secondary wire should not be wound close to the head, a space of about ⅛ inch should be left. After winding one of the sections of the seconday coil, the other may be proceeded with after changing ends with the spool in the lathe, so that one section may be wound as a continuation of the other. The inner terminals are connected at H, and soldered; the outer terminals are connected with

FIG. 1.



PLAN OF INDUCTION COIL.—HALF SIZE.

FIG. 2.

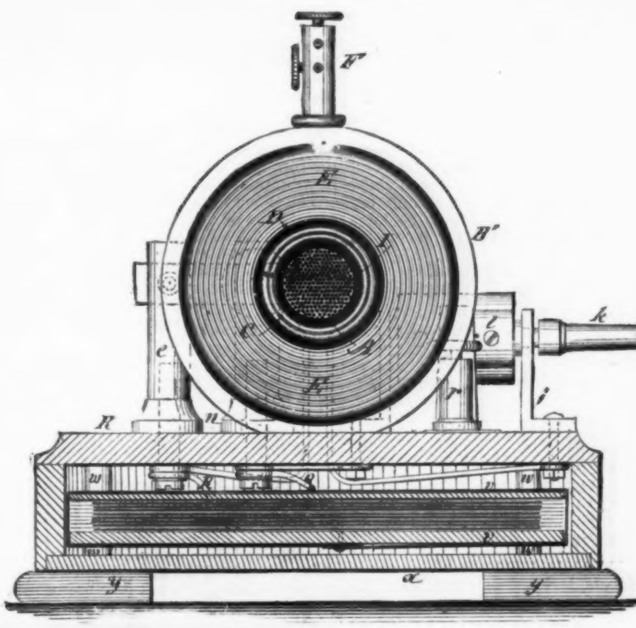


LONGITUDINAL SECTION OF INDUCTION COIL.—HALF SIZE.

the binding posts, F, which are screwed into the upper edges of the heads, BB'. For the sake of strength the outer ends of the secondary wire may be four or six sizes larger than that of the coil. The outer layers of fine wire are each partly covered with a paper band, consisting of six layers of tea paper, which is wide enough to reach from the head over about two-thirds of the coil section; the whole is then enveloped in a wrapper of stout paper, having a hole directly in the middle at the top, through which is poured melted resin to which has been added a very small quantity of beeswax.

This forms the insulating medium, G, which prevents the

FIG. 3.



TRANSVERSE SECTION OF INDUCTION COIL.—HALF SIZE.

spark from leaping from one section of the coil to the other. After the resin cools, the thick paper is removed and a covering of smooth heavy paper is neatly put around the coil, and upon it is wound as closely together as possible common smooth finished black thread. This latter is not essential, of course, but it gives the coil an excellent appearance and forms a really good covering.

In the tube, A, is placed a bundle, I, of No. 18 soft iron wires. They should be straight and of the same length, and their outer ends especially should be exactly even. The central hole in the head, B, is stopped by a wooden plug or button, J. The base, K, consists of a wooden box, neatly made, and the size of which may be readily obtained from

FIG. 4.

DIAGRAM OF CONNECTIONS, INDUCTION COIL.

the engravings. The coil is secured to the top of the box, a little nearer one end than the other, by two screws, *a b*, which pass upward into the heads, BB'. Near the head, B', there is a brass standard, *e*, to which is secured one end of the spring, *f*, that supports the iron hammer, *f'*, exactly opposite the center of the wire bundle, I, and about ¼ inch distant from it. Opposite the middle of the spring, *f*, and ½ inch from it, there is a post, *n*, through which passes the platinum pointed screw, *o*, which touches a small platinum plate, riveted to the center of the spring, *f*. The post, *n*, is split-longitudinally, and clamps the screw, *o*, with some little pressure to prevent it from jarring loose by the vibrations of the spring, *f*.

The commutator, L, consists of a vulcanite cylinder on which are screwed two copper bars, *l m*, one of the screws of the bar, *l*, coming into contact with the pivot, *g*, and one of the screws of the bar, *m*, coming into contact with the pivot, *h*. The pivots, *g h*, turn in posts, *i j*, which spring against the shoulders of the pivots to insure a perfect contact. The pivot, *h*, is elongated and provided with a vulcanite handle, *k*. The binding posts, *r s*, are connected by copper springs, *p q*, with the copper bars on the vulcanite cylinder.

In the base of the instrument is placed the condenser, M, which is composed of sheets of thin tin foil alternating in position as shown in Fig. 4. The ends of the sheets, O, projecting beyond the sheets, P, to the right, the ends of the sheets, P, projecting beyond the sheets, O, to the left. The sheets, O, are insulated from the sheets, P, by sheets of paper, N, which have been coated with shellac varnish and well dried. While the sheets O, do not touch the sheets, P, the latter are all connected together at one end, and are in electrical connection with the wire, Q. Similarly the sheets, O, are connected with the wire, R.

A piece of pasteboard, *v*, is placed upon each side of the condenser thus formed, and the whole is fastened together with tape running around it in two directions, and the condenser is held in place by bits of cork, *w*, which are pressed by the bottom, X, when it is in its place. The condenser has 40 square feet of tin foil surface. The connections are made as follows: the battery wires are connected with the binding posts, *r s*, the current passes through the springs, *p q*, bars, *l m*, pivots, *g h*, to the posts, *i j*. The post, *j*, is connected directly with the terminal, *c*, of the primary coil, C. The post, *i*, is connected by the wire, *t*, with the post, *n*, and the terminal, *d*, of the primary coil, is connected with the post, *e*. The battery current passing through the primary coil renders the wire bundle, I, magnetic; the hammer, *f'*, is attracted toward it, breaking the electrical connection at the end of the screw, *o*, when the iron wire bundle loses its magnetism, and the hammer flies back until the spring, *f*, again touches the screw, *o*, when the hammer is again attracted, and so on. When the current is broken in this manner, if the condenser be detached, there is a large spark at the end of the screw, *o*, as the extra current is discharged from the primary coil; but when the condenser is connected by the wires, Q R, with the posts, *e n*, the spark is very much decreased in intensity, as the extra current is diffused in the condenser, and the strength of the secondary current is very much increased.

The binding posts, F, have each two holes and two binding screws. One set of holes receive the pointed rods, S, the other the conducting wires, T. This coil, if carefully made, will, when the current is interrupted, give a spark 1½ inches long between the points of the two rods, S, by using two large Grenet battery cells. The current may be reversed by turning the pole changer or commutator, L, through a half revolution, and it may be stopped altogether by turning the bars, *l m*, out of contact with the springs, *p q*.

It requires nearly a pound of wire for each section of the secondary coil; but, of course, the quantity will vary somewhat with the manner of winding. By observing the proportions, given coils of other sizes may be made from these drawings.

Another method of winding, to which I shall allude only briefly, consists in winding silk covered wire entirely across the spool, and insulating each layer by a coating of shellac, and two or three thicknesses of paper coated with shellac varnish or melted paraffin. Still another method consists in making the secondary coil of very thin sections, and insulating the sections one from the other by disks of hard rubber; but the plan here given is undoubtedly the easiest, and a coil made in this manner gives good results. With it most, if not all, of the experiments usually performed with induction coils may be accomplished.

For example, it will charge a Leyden battery, decompose water, explode blasting cartridges, light gas, exhibit the phenomena of electric light in vacuo, and may be used in many very interesting experiments.

SCIENTIFIC AMERICAN SUPPLEMENT, No. 166, will contain instructions for performing a number of interesting experiments with the induction coil.

ON THE MINUTE MEASUREMENTS OF MODERN SCIENCE.

By ALFRED M. MAYER.

ARTICLE XVI.

On the determination of the number of vibrations made in a second by a tuning-fork; with examples of the uses of the tuning-fork as a chronometer to mark and register minute intervals of time.

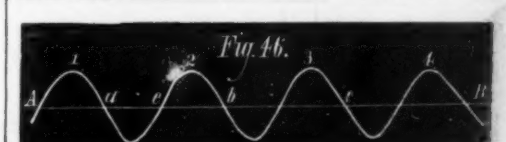
IN a subsequent article I purpose to show how, with revolving-mirrors, rotating-disks, and tuning forks, men of science have measured the minute intervals of time occupied by electric flashes, and have found out something as to the structure and compound nature of these flashes.

To make such investigations we must first of all provide ourselves with instruments whose parts will move so quickly that they can keep pace with these sudden and violent electrical motions, and also register the very minute times during which they exist.

A tuning-fork is an excellent chronometer, and when used skillfully will accurately measure intervals of time as minute as the 1-20,000th of a second. How a tuning-fork can serve as a time keeper the reader will readily understand after making the following experiment.

Take a tuning-fork the number of whose vibrations in one second we know. Suppose that it makes exactly 500 vibrations in one second. By a vibration we understand a to *and* fro motion of a prong of the fork. It is thus understood in this country, in England, and Germany, but in France a vibration is a to *or* fro motion of a prong of the fork. Blacken a piece of window glass by moving it about in the smoke of burning camphor, or in the smoky flame of a kerosene lamp. Tip one of the prongs of the fork with a delicate point made of a triangular piece of thin copper foil. Now vibrate the fork and quickly draw the tip of foil over the smoked surface. On holding the glass up to the light you will observe that the lampblack has been brushed by the tip from off the glass, in a sinuous or wavy line, as shown in a very enlarged scale in Fig. 46.

Each vibration to *and* fro of the fork made a part of the trace as long as from 1 to 2, or from 2 to 3, etc., or, what is



the same, as long as from *a* to *b*, from *b* to *c*, or from *c* to *d*, measured on the axis, A B, of the curve. As the fork makes 500 of these double flexures in one second, it makes one of these double flexures (say from *a* to *b*) in the 1-500th of a second, and a single flexure (say from *a* to *c*, or from *c* to *b*) in 1-1,000th of a second. Thus it is evident that if we know the exact number of vibrations made by the fork in one second, we can use its wavy trace as a measure of the flow of time.

The velocity of rotation of a wheel measured by a tuning fork.—For an example, suppose we desire to know the velocity of rotation of the wheel of a gyroscope. Coat its disk or rim with lampblack, and touch the rotating wheel with the tip of foil on the prong of the vibrating fork. On counting the number of the flexures marked by the fork in the circumference of the wheel we have the number of thousandths of a second which the wheel took to make one revolution. Suppose we have found 25 flexures in the circumference of the wheel. This shows that the wheel made one revolution in 25-1,000ths, or 1-40th, of a second. In this very manner Dr. Thomas Young measured velocities of rotation in 1807. To this illustrious man of science is due the idea of using a tuning fork for a chronoscope, and the first published notice of this invention is found in his "Lectures on Natural Philosophy and the Mechanical Arts," London, 1807.

Evidently the knowledge of the exact number of vibrations made by the fork in one second lies at the foundation of this method of chronometry. To make this measure various methods more or less accurate have been devised,

which we have not the space to enumerate. We will at once proceed to describe one which we consider as the most accurate that has been invented.

If it were possible to make a cylinder rotate with absolute uniformity of motion, and if we had the means of knowing the exact time taken by it in making one revolution, we might readily determine the number of vibrations made in one second by a fork. We would merely have to count the number of waves in the trace of the fork extending around the circumference of the smoked cylinder. This method has been tried; but all who have employed it have acknowledged the impossibility of getting a cylinder to revolve with sufficient uniformity for the purpose, and the difficulty of ascertaining the time occupied by the cylinder in one revolution.

A better plan is to let the cylinder revolve as it will, and to obtain the time not from the motion of the cylinder but from the fork itself. This is accomplished by sending at each second, through the intervention of a clock, a small spark of electricity from the tracing point of the fork on to a revolving metallic cylinder coated with smoked paper, and thus marking the exact intervals of seconds on the trace of the fork itself. By counting the number of flexures contained in the length separating two of these sparks we have the number of vibrations made by the fork in one second. A little consideration will show you that the velocity, whether slow or fast, uniform or irregular, has no influence on the determination of the number of vibrations of the fork, for an increase or diminution in the velocity of the cylinder does not change the *number* of the vibrations of the fork, but merely draws them out or crowds them together in the distance contained between two spark holes.

The manner of applying this method is as follows: At C, of Figs. 47 and 48, is a brass cylinder covered with paper, which is smoked by rotating the cylinder over a camphor flame. The foot of the fork, F, is screwed into a piece of hard wood, H, hinged at *h* to a base board. A triangular piece of platinum tipped foil is cemented to one of the prongs of the fork. This tip just touches the surface of the smoked paper, so that when the cylinder is revolved under the vibrating fork the latter makes its wavy trace on the smoked paper, as shown, very much magnified, on the cylinder of Fig. 48.

The cylinder turns on an axle which has a screw thread, cut on its length, S. This screw turns in a nut cut in the standard, T. On turning the crank handle, V, the cylinder revolves, and at the same time is moved horizontally by the action of the screw, S. By these motions the trace of the fork does not return on itself, but is written on the cylinder in a helical line, which is a reproduction of the screw, S.

edges smoothly gummed together. Then the paper is smoked by traversing the cylinder over burning camphor placed in the interior of a little tin chimney. The battery connections are now made, the fork is vibrated by drawing a violin bow across its prong, and the cylinder is revolved. At each second a spark will be seen to flash out from the style attached to the fork. After the cylinder has been revolved through its whole length under the fork, the smoked paper is removed and (after writing on its smoked surface the number and character of the experiment) it is drawn through spirit varnish to fix the trace on the paper. If the paper is examined after one of these experiments, you will observe a minute white disk at each place where the spark flashed on to the paper, and on holding the paper between you and the light you will see that the center of each of these little white disks is perforated with a minute and clear round hole. This spark hole, when obtained as we have directed, is a very sharply defined point, so that it is not difficult to count the number of flexures between two holes to as near as 1-10th of the length of a flexure. It is indeed very interesting to see how the spark marks the exact beginning or end of a second, sometimes at one point, sometimes at another of the bend of the wavy trace.

After the paper has dried the count is made of the number and the fractions of waves contained in the length separating the spark holes. This count is made easier and less liable to error by marking off the waves contained between two spark holes into groups, each containing ten whole waves. The record on one sheet generally contains the traces made by the fork during twelve successive seconds.

As examples taken from actual determinations of the numbers of vibrations of forks we give the following tables of experiments:

A.	B.	C.
(1)	255·00	255·95
(2)	256·90	
(3)	255·05	255·97
(4)	256·90	
(5)	254·90	255·90
(6)	254·90	
(7)	254·70	255·92
(8)	257·15	
(9)	254·95	256·02
(10)	257·10	
(11)	254·90	256·02
(12)	257·10	
Mean		255·96

The first column of numbers, inclosed in parentheses, de-

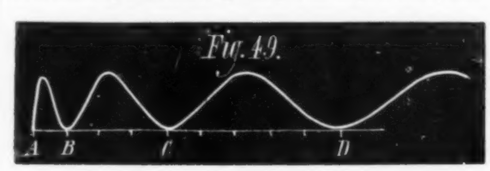
vibrations in a second. Our experiments show that when this fork was loaded with tip of foil and was scraping the lampblack off the paper it made 255·96 vibrations in a second at the temperature of 74° Fahrenheit. When the tip is very delicate and is so carefully adjusted that it just brushes the black off the paper, its effect on the time of vibration of the fork can barely be detected.

One cause of change in the number of vibrations per second of a fork is due to a change in its temperature. This, however, is fortunately very slight in its effects. We have found from many very carefully made experiments that an elevation of one degree Fahr. in the temperature of one of König's forks diminishes its vibratory period by about the 1-22,000th part.

The extent of the swing or amplitude of the fork's vibration has no appreciable effect on its time of vibration. Thus, in the experiments contained in the above table the extent of the swing of the fork during the first and second seconds averaged about two and a half millimeters, while in the eleventh and twelfth seconds it averaged only one half millimeter. Yet there is a difference of only 4-100ths of a vibration in a second. In the above series of experiments it appears that the fork moved a little faster as it ran down in amplitude, but this really shows nothing, for on examining any dozen series of similar experiments it will be found that the fork as often goes slower as faster as the amplitude of its vibrations gradually diminishes.

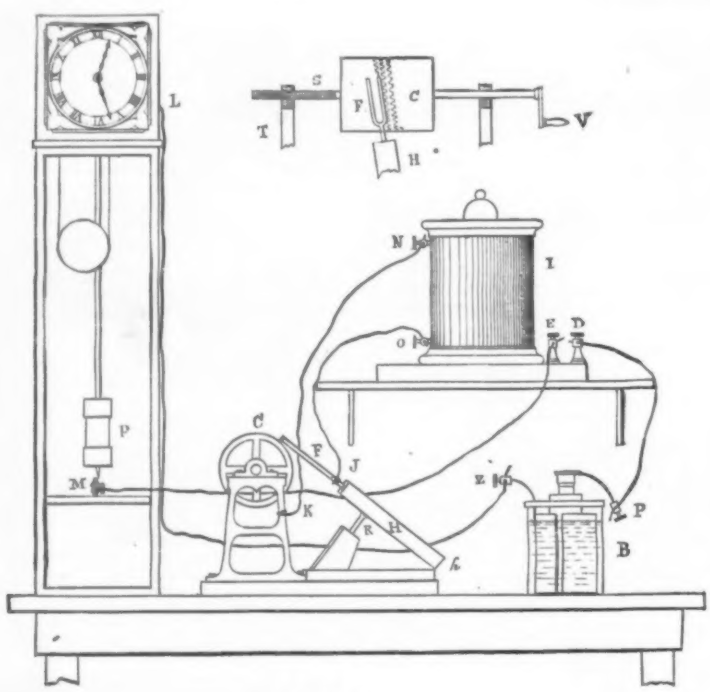
The above facts are sufficient to convince any one of the great value of a tuning fork as a chronometer which both marks and records minute intervals of time. It is a chronometer which requires to be regulated but once; that is, we have only once for all to determine the number of vibrations it makes per second at a known temperature. It does not get out of order, for if kept from rust it will, as far as we know, have the same rate ten years hence as it has to-day.

The laws of falling bodies written on a falling plate by a tuning fork.—We will give a few examples of its application to such purposes. We have already shown how the trace made by a vibrating fork on the rim of a wheel will give its velocity of rotation. In this case the velocity may be considered as uniform during one revolution. But variable motions are as readily studied. For example, if a plate of glass fall vertically, it will have a gradually increasing velocity so that the spaces it will describe in successive equal portions of time will be as 1 : 3 : 5 : 7 : 9, etc. This is readily shown by allowing a smoked plate to fall freely, while the style on a vibrating fork wipes off the lampblack from its surface. After the fall of the plate it will be seen that the successive waves made by the fork (beginning with its *first* wave) have



lengths which are as 1 : 3 : 5 : 7 : 9, etc. But the time in which the fork made each of these waves is the same, hence the respective *lengths* of these waves show the respective distances through which the plate fell in successive small and equal portions of time. Instead of allowing the plate to fall near the stationary fork it may be more convenient to make a fork fall near a stationary vertical plate. The fork may be screwed into a board, whose lower edge is loaded with a bar of lead. The board must run accurately in vertical guides. With such a simple instrument may be shown all the laws of falling bodies.

Fig. 49 gives the exact appearance of a trace made by a fork, or rather, by a vibrating steel rod, on a smoked glass plate which fell near it. It will be remembered that each of the half waves, A B, B C, C D, was made in the same period of time, but the spaces, A B, B C, and C D, are of different lengths, for they are really the distances through which the plate fell with a uniformly increasing velocity in equal portions of time. A scale of equal parts is drawn on A D, with the distance from A to B taken as its unit. The reader will observe that while A B contains one unit of length, B C contains 3, and C D contains 5. This curve shows in a very simple and neat manner that a body in falling vertically by the action of gravity goes over spaces in equal successive portions of time, which are of lengths as 1 is to 3, is to 5, is to 7, and so on. If after the experiment you flow spirit varnish over the smoked plate you will have a permanent record of the law of falling bodies written by Nature herself.



FIGS. 47 and 48.

The spark is sent through the wavy trace of the fork by the following arrangement of apparatus: At L is a clock, beating seconds. The pendulum of the clock is formed of a rod of steel screwed into an iron cylinder, P, nearly filled with mercury. Attached to the bottom of this cylinder is a triangular slip of platinum. The point of this slip, when the pendulum is vertical, goes into a globule of mercury, shown sticking at the top of the binding screw, at M. A cell of a voltaic battery is at B. From this cell, at P, a wire goes to D, one end of the primary coil in the inductorium, I. From E, the other terminal of the primary coil, the wire leads to M. When the pendulum is vertical it makes electrical connection with M and the works of the clock. A wire, L, joins the clockwork with the other pole, Z, of the battery. From this arrangement it is evident that whenever the pendulum, P, reaches the vertical, it enters and quickly leaves the globule of mercury, M, and by so doing it sends a momentary current of electricity into the primary coil of the inductorium. At the instant the platinum point attached to the pendulum *leaves* M, an electric current is sent from the secondary coil of the inductorium from O to the fork at J, thence it goes, *as a spark*, from the tracing tip on the fork *through the paper* to the cylinder. The latter is connected to the other terminal of the secondary coil of the inductorium by a wire leading from K to N. Thus, at each second a spark flashes from the tracing style of the fork and makes a small and sharply cut hole through the paper, directly in the wavy line which the fork traces. This electric flash must be formed of *one* spark, and this must be minute. This character of spark is obtained by using a small voltaic cell, and by interposing a sufficient electrical resistance between it and the inductorium.

To make a measure of the number of vibrations per second of the fork we proceed as follows: The cylinder is neatly coated with finely woven and thin printing paper, with its

notes the successive seconds. The second column contains the number of vibrations made by the fork during these seconds. It will be observed that these numbers are alternately small and large; thus (1) = 255; (2) = 256·9; while (3) = 255·05; and (4) equals 256·9; and so on. This is so because the drop of mercury is not exactly in the center of the arc of vibration of the pendulum. This matters not, however, because the time by which the record of the first second is short of an exact second is added to the record of the next second; so, if we take the mean of the number of vibrations recorded in the first and second seconds, in the third and fourth, in the fifth and sixth, and so on—as we have really done in the third column of the above table—we will have the exact number of vibrations made by the fork in a second.

At the bottom of the third column is placed the mean of the means contained in this column, and this of course is taken for the final result of the determination as given by this series of experiments.

The difference between the largest number and the smallest in the column of means is 256·02 minus 255·90, which is only 12-100ths of a vibration. As the fork makes one vibration in 1-256th of a second, it follows that this extreme difference of 12-100ths of a vibration is, in time, only the 1-2,133d of a second. Calculating by the method of least squares the average error made in a single experiment, we find it equals plus or minus 3-100ths of a whole vibration of the fork; while the error of the mean of the whole twelve experiments amounts to only 1-77th of a vibration. One seventy-seventh of the 256th of a second is about the 1-20,000th of a second.

The above experiments are fair examples taken from scores of similar series which we have made on the forks of König of Paris. The fork used in the experiments given in the above table was stamped by König as giving 256 complete

The velocities of cannon balls measured by the tuning fork.—It is evident that one of the conditions of efficiency of an army is that it shall be furnished with the best arms, ordnance, and gunpowder. To form accurate comparisons as to the relative merits of various forms of arms and cannon, and of powder of different compositions and structure, it is necessary to compare the various velocities given to the balls. For this purpose nothing answers so well as *the tuning fork chronoscope*. A fork, the number of whose vibrations is accurately known, is mounted with a delicate style touching a cylinder like that shown at C, in Figs. 47 and 48. Instead, however, of the primary circuit in the inductorium being broken by the pendulum, P, as in those experiments, it is broken by the ball passing through targets made of stretched wires placed at known distances apart. At each rupture of the wire of a target a spark flashes from the fork and makes a hole in its trace. At the next instant the electric circuit is closed by an electro-magnet before the ball has reached the next target, and so on in order at each target the circuit is broken and then instantly closed. After the flight of the ball through all of the targets, the number of waves contained in the spaces separating the successive spark holes is counted. These numbers multiplied by the time it takes the fork to make one vibration, give the times which the ball took in going through the distances separating the successive targets.

The speed with which the nervous motor and sensitive agent travels along the nerves measured with the tuning fork.—In physiological experiments the tuning fork is the chronometer which is universally used when minute intervals of time have to be accurately measured. The fork has timed the speed of the nervous motive agent and the velocity of the contractile waves in the muscles. To understand how such measures are made imagine a revolving cylinder whose smoked surface is touched by the longer arm of a delicate lever. The shorter arm of the lever rests on a muscle in which motion can be caused by the irritation of a certain nerve. This nerve we can excite at two points which differ

by several centimeters in their distances from the muscle. The tipped prong of a tuning fork writes its trace on the revolving cylinder just below the line which is described on the cylinder by the long end of the lever when stationary. It is evident that when the muscle contracts the lever is tilted, and its end which touches the cylinder leaves the straight line which it was tracing to return to it when the muscle relaxes. On the cylinder is a projecting piece of metal which in its revolution with the cylinder comes in contact with another fixed piece of metal and then sends an electric discharge into the nerve. Now, suppose we thus

FIG. 50.

excite the nerve at the point which is nearest the muscle; the latter contracts and moves the lever. This motion of the lever takes place a certain interval of time after the irritation of the nerve. If we now irritate the nerve at the point more distant from the muscle we will find that a longer interval of time exists between the irritation of the nerve and the motion of the lever. The difference in these two intervals of time is the time required by the nervous agent in traversing the space between the two points on the nerve.

Fig. 50 gives a representation of the graphic results of an experiment on the speed of the nervous motive agent in man, and may serve to give a clear conception of these interesting experiments. At the same time it shows the velocity of the nervous motive agent, the time required for the muscle to move after the nervous agent has reached it, and also the character of the motion a muscle has during its contraction and elongation.

The horizontal line is the line made on the cylinder by the end of the lever when the latter is stationary. When the lever is moved by the contraction of the muscle it is deflected above the horizontal line, and then draws one of the curves shown in the figure. It will be understood that the smoked surface on the cylinder is moving from right to the left of the reader; hence the steep side of the curve is made on the contraction of the muscle, while the gradual descent toward the horizontal line is made during its elongation. This shows that the muscle contracts faster than it elongates.

The electric discharge into the nerve is made when the tracing point of the lever is on the vertical line, C D, but this point does not move till it reaches A in one experiment and B in the other. The motion of the lever at A was caused by the irritation of a point of the nerve quite close to the muscle, while its motion at B was caused by another experiment when a point of the nerve 30 centimeters farther removed from the muscle was irritated. Referring to the figure the reader will see that the fork wrote two and a half of its waves in this interval, A to B. As the fork made 250 vibrations in a second, it follows that the nervous motive agent in man goes over 30 centimeters in 1-100th of a second; or, has a velocity of 30 meters in one second. This speed is about that of the fastest railway trains in England.

In the above experiment the point of the nerve nearest the muscle was quite close to the shorter arm of the lever. If the lever had moved at the instant the nervous agent acted on it the deflection above the horizontal line would have taken place at the line, C D, instead of at A, as really occurred. This shows that it takes quite an interval of time for the muscle to move after the nervous agent has reached it. The distance from C D to A represents an interval of time a little over one hundredth of a second. This sluggishness of the muscle to obey the nervous agent has been called by Helmholtz *the lost time.*

The velocity with which the nervous sensitive agent is conducted along the nerves is about the same as that of the speed of the nervous motor agent. This fact opens curious reflections as to the interval of time which must always exist between the irritation of a nerve and the sensation caused by it. For example, if a man should have his toe cut off without his seeing the act, he would not be signaled of his loss till about 1-16th of a second after it had happened; then it is supposed that the brain requires about 1-30th of a second to receive and interpret the message and to order the foot to move. The sending of the order over the nerves will take another 1-16th of a second. After this order (or stimulus) has reached the foot, 1-100th of a second will elapse before the muscles of the foot can move. Adding together all of these intervals of time we find that 1-6th of a second will intervene between the injury to the foot and its motion. In reptiles the velocity of the nervous agent has probably about one half of the speed it has in man. Some of the serpents of the *Boidæ* family grow to 30 feet in length. If with a stealthy and sudden cut we should deprive one of these creatures of the tip of his tail, it is likely that a whole second would elapse before he could retract his body. In the above curious reflections we have assumed that no reflex action occurs in these phenomena to render inaccurate the computations which we have made.

COLLIN'S CITY TIME REGULATOR.

THE problem of how to regulate uniformly the time of the different clocks of large cities, so that at least several times a day they correspond exactly to each other, has always been of difficult solution.

The action of compressed air has been employed without satisfactory results. Later, the ordinary electro-magnetic chronometers were invented. Although tolerably precise in their action, when applied to a limited number of clocks, they failed as soon as they were required to unify the time of a more extended territory; besides, an omission of the correction having once occurred, it was not made good by the next regulation taking place, another omission would again increase the error, and thus the difference would sometimes accumulate within a few days to the same extent, as without electrical regulation.

There were exhibited at the Paris Exhibition several devices of a novel character, intended to do away with these difficulties, of which the most interesting are that of Foucault and Vérité, and that of Mr. Collin. The former is admirably adapted to all scientific and other purposes, where the greatest possible exactness is required. Its regulation takes place every second, thereby reducing the greatest possible inaccuracy to a minimal fraction of a second. The apparatus of Mr. Collin, which we illustrate above, corrects the time every hour only, but is of sufficient exactness for all ordinary purposes. Its simplicity makes it especially adapted to the unification of time of a large number of clocks, as in a large city.

The clock to be regulated, represented in Fig. 1, is arranged so that it has a very slight tendency to run ahead of the regulator, shown in Fig. 2. Every hour, as soon as the minute hand reaches 12, an electric mechanism stops the escapement wheel; thus the balance swings free, without effect, till the hand of the regulator has also arrived at 12. Then the circuit is broken again, and the two clocks move on perfectly synchronically. Nothing can be more simple than this contrivance. Should, for some reason or other, the action be omitted, the entire error will be corrected the next time it takes place again.

As the engraving shows, nothing has been altered in the mechanism of the clock proper. The electro-magnetic instrument is situated on a platform supported by the general frame. The interrupter is placed above the dial, resting on an eccentrical disk, moving simultaneously with the minute hand. Its most eccentrical point reaches the noon point exactly with the minute hand.

The armature of the electro-magnet is provided with a long lever, bent at its end in a right angle, so as to engage the teeth of the escapement wheel. The electro-magnet connects at one end with the arm below the interrupter, at the other end with the second wire of the circuit; the first wire of the latter connects with the interrupter arm resting on the eccentric.

The circuit is completed by the electric battery and the interrupter of the regulator (Fig. 2).

The interrupter of the latter is composed of two levers, the lower one of which also rests on an eccentrical disk. As long as it slides on the jutting part of the latter it remains in contact with the upper lever, but, when it drops down at the end of each hour the contact is severed, the circuit broken, and thereby the lever in the clock, Fig. 1, is caused to release the escapement wheel, upon which the clock moves on. The arm situated above the interrupter in Fig. 1 is not necessary, where only a single clock is to be regulated by the standard mechanism. In a complicated system, however, it acts as conjunctor of current.

It is obvious that this mechanism may be easily applied to all kinds of clocks, without increasing materially the cost.—*L'Electricité.*

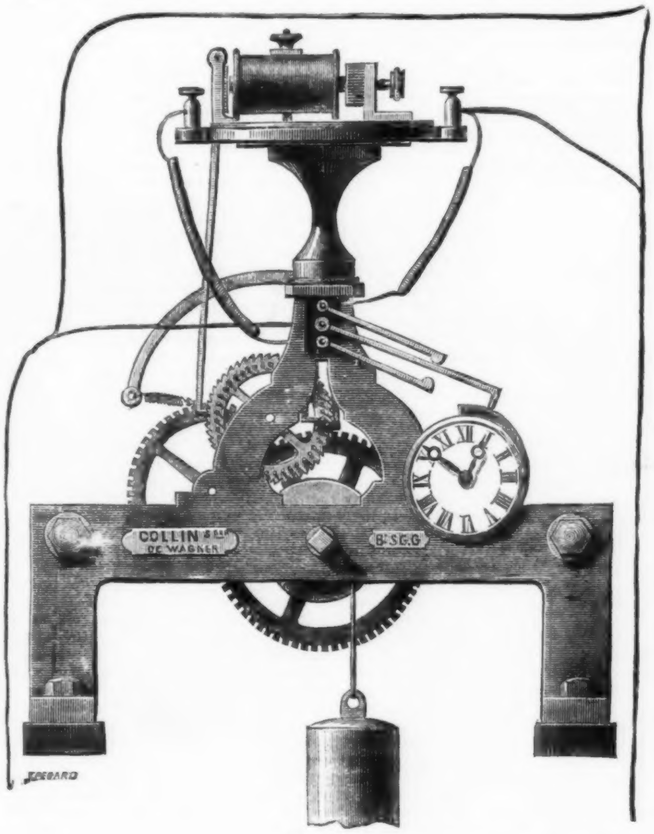


Fig. 1.

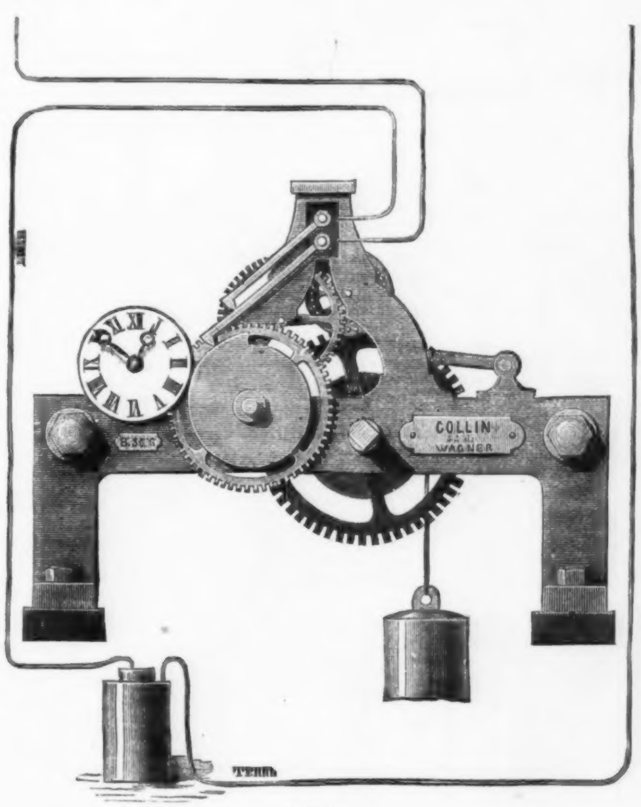


Fig. 2.

COLLIN'S CITY TIME REGULATOR.

STROUMBO'S APPARATUS FOR DETERMINING THE MAGNETIC INCLINATION AND DECLINATION.

THIS instrument, invented by Prof. Stroumbo, of Athens, Greece, and represented in the engraving on next page, serves to demonstrate the declination and inclination of the magnetic needle at different localities.

It consists of a horizontal graduated ring, H, and a vertical, graduated semicircle, V, which are firmly fastened together and supported by a tripod. The feet of the latter are provided with screws, X, by which the position may be regulated. In the ring plays an ordinary magnetic needle, while another one, provided with a lateral axis resting on supports formed by pieces of agate stone, as shown in the engraving, plays in a vertical plane. Both needles must be as much as possible of the same size and weight, and one at a time only must be used on the instrument. O is a brass plate, provided with a minute opening. Directly opposite is a vertical frame, P. Through the center of its open space is extended a horse hair, in front of which slides a marker, G. The frame, P, is divided into minute degrees on its entire length, beginning from zero, the zero point being in a horizontal line with the opening in O. The line, O P, is situated directly above the line, 0°—0°, of the scale, H, and is parallel to the vertical scale, V. The graduation on P gives the angles, formed by a line drawn from O to any point of the scale with the horizon.

To find the declination we proceed as follows:

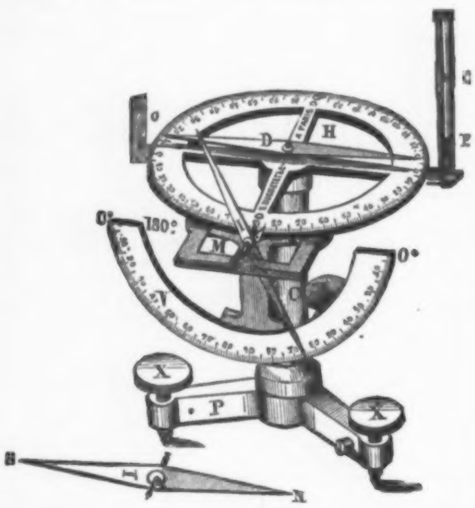
The needle, I, being removed, the needle, D, is left to play, till it comes to rest. Then the instrument (or, in case the upper part is made movable, the scales, H and V), is turned, till the points of the needle are situated directly above the points, 0°—0°, of the scale, H. The direction indicated by the needle, D, is the *magnetic meridian* of the place of experimenting. A plane drawn through the same vertically passes through the center of the earth. The north is indicated by the blue end of the needle. As is well known, the magnetic meridian differs from the geographical meridian of the earth, a plane laid through the latter falling in that of the earth's axis. The angle formed by the two meridians is called the *magnetic declination.* To determine the latter, we must hence find the geographical meridian. This is done as follows: The apparatus being in horizontal position, a line of vision is drawn to a known star near the horizon, noting the point at which the line crossed the scale, P, as also the exact moment of observation and the angle formed by the needle, D, with the line, 0°—0°, on the scale, H. By means of the necessary astronomic tables the angle, formed by the plane laid through the opening, O, the horse hair at P and the star with the geographical meridian, may be found, from which the angle formed by the latter with the magnetic meridian may easily be calculated.

The declination is called western, when the blue point of the needle falls between N and W; eastern, when it falls between

N and E, the direction N S being coincidental with the geographical meridian. At points, the geographical meridian of which passes through the magnetic poles of the earth, the declination is = 0.

To find the inclination, the needle, D, is removed, after the instrument has been placed so that the line, 0°—0°, of the scale, H, falls into the magnetic meridian. The scale, V, being parallel to the line, 0°—0°, and perfectly vertical, the needle, I, may swing free in a vertical plane when suspended by its axis in its support. The blue point of the needle will turn downward, and, after oscillating freely, will come at rest on a point of the scale at a greater or smaller distance from the point 90°. This point indicates the *inclination* of the *magnetic needle* for the place of experiment, expressed by the size of the smaller angle formed by the needle and the horizontal line, 0°—180—0°.

The instrument is now turned around its center 90°. This is done by taking off the needle, I, replacing the needle, D, and turning the apparatus till the points of the needle are situated directly above the points 90°—90° of the scale, H. The needle, D, is now taken off again and needle, I, replaced.



It will oscillate in a plane perpendicular to the magnetic meridian, and, when at rest, adopt a vertical position, the effect of the magnetic influence of the earth being counteracted by the resistance of the supports of the needle, J. As soon as the position of the instrument is changed, the influence of terrestrial magnetism will make itself felt again. Thus the magnetic meridian may be easily determined by the plane in which the inclination needle rests in a perfectly vertical position, this plane being exactly perpendicular to the magnetic meridian.

Declination and inclination vary at the same places in the course of years. The inclination is = 0 at the equatorial line, and increases toward the magnetic poles of the earth.—*Les Mondes.*

A BREATH BATTERY AND TELEPHONE.

AMONG the numerous inventions made since the telephone became famous, we find one which is the invention of Mr. C. W. Harrison, of South Kensington, London, which is so far remarkable that the patentee claims to produce a thermo-electric beat corresponding to the electric undulation created by the sound-wave of the ordinary telephone.

The first part of the invention relates to the construction of an electric telephone of great sensitiveness and simplicity by utilizing a thermo-electric battery arranged in a manner suited to the object in view. One method by which the patentee was enabled to carry on conversation at a distance through a connecting wire or line consists in speaking direct upon the electrodes of a thermo-battery, or upon one of the electrodes, or upon some suitable surface connected with them, and thus producing from the warmth of the breath a thermo-electric beat or wave corresponding with the air-wave produced by the voice.

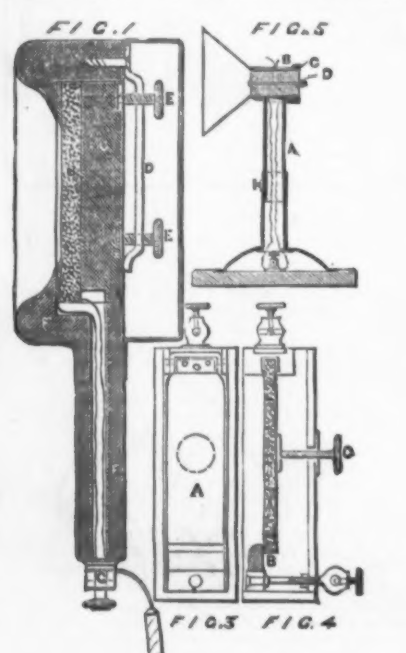


Fig. 1 is a transverse sectional elevation of a thermo battery in its simple form, which the patentee finds well adapted for the purposes of his invention. A is a ring of amalgamated copper, lead, or other suitable metal, in slight adjustable contact with a disk of carbon, B, which is attached by glue, or by other suitable means, to a block of wood, C, the adjustment of the contact between the electrodes being effected by the screws, E, passing through the bridge, D. The face and handle, F, are of wood, the former having the form shown to guide the air-waves, and the latter being bored out to allow the wires from the two electrodes to pass down the terminals, G, to which also the line wires, H, are connected. The words to be conveyed should be directed toward and spoken near to the face of the carbon plate, B.

Fig. 3 is a front elevation, and Fig. 4 a side elevation of another form of the single pair electrode thermo-battery, in which the mechanism is constructed of great delicacy and lightness, so that a very faint sound will cause it to act efficiently. A is a carbon plate, suspended on pivots at its upper end, and when vertical is in very light contact with a shoe, B (carbon-faced), which is capable of adjustment relative to the plate, A. When the shoe is drawn toward the plate, A, the latter is put out of the vertical, and so presses more on to the shoe, giving greater contact. The adjustment may be further effected by the set screw, C. The patentee has also devised a thermo-battery with six pairs of elements. These consist of wires attached and in contact by hook-and-eye arrangement, the wires passing round a block of wood with a terminal at each end, to each of which an end wire is attached, the wires being alternately different metals, by preference amalgamated copper and platinized lead. In a similar battery, the alternate wires, instead of being connected by hook-and-eye arrangement, have their ends laid in contact in pairs in carbonized grooves burnt in the face of a block. In some cases when it is desired to increase the effect by a more powerful current, the patentee uses in addition to the warmth of the breath that of the thumb and finger, by touching the electrodes or the terminal; he thus produces continuous current to be varied by the waves of sound and heat emanating from the breath. In all these forms of thermo-battery the warmth of the breath should be brought to bear on the electrodes.

Another part of the invention relates to the employment of flat or other spirals or coils of wire attached at each end or at stations on the line wire. The words to be conveyed are spoken on to one or more of these coils, and received at the other end by similar coils. Other sounds may be similarly conveyed. The coils may be employed with or without a local battery. Sometimes the coils are made a source of electricity by being constructed compound, *i. e.*, of more than one metal, or by coating them with magnetic sand, or by other suitable means. In his experiments Mr. Harrison has found that the conducting wire of the circuit will produce sonorous vibrations in accordance with the variations in the current. For this purpose he prefers that the spiral should be of soft iron, and that it should be stretched over a sounding board with a moderate degree of tension. The spiral is supported at intervals of the nodal points, or it may be so constructed in sections, the supports or ends of each section resting in light contact with said supports or with each other, so as to prevent increased resistance to the passage of the current at such nodal points. In place of using one uniform size and quality wire, the patentee finds it advantageous to use in each of the several sections wire of different thicknesses in proportion to the pitch of the notes; these wires may be straight or bent, with their nodal points or ends resting on blocks of carbon, each block being in the circuit of the current which is dispersed at these points according to the unison of pulsation and vibrations. In the course of his investigations he has found that these spirals may be used in circuit with the sound of a standard clock, and thus form correct chronophones for repeating the hour in different places.

Fig. 5 illustrates a vertical sectional elevation of a receiver constructed according to the invention. A is the stand capable of adjustment as to height, as shown. Surmounting the top is a horizontal cylinder, B, filled with disks of carbon, C, through the center of which passes a rod, D, at one end of which is a button, E, of vulcanite or ivory, and at the other a screw thread and nut, by which the contact of the disks may be increased in pressure or diminished. F is the mouthpiece for directing the sound-waves on to the disks of carbon. From each of the end disks a wire is led down to a terminal at the base of the instrument. The current passes through the instrument, and the air vibrations entering the mouthpiece are communicated to the current, causing undulations.

Mr. Harrison calls this instrument a receiver, but it would appear to be a transmitter. The receiver, however, is presumably Bell's telephone, as the patentee says that the sounds transmitted may be repeated by any known suitable means. A convenient arrangement of repeater for this purpose consists in an electro-magnet and metal diaphragm, which latter he prefers to make of well-annealed iron, as bare as possible; this is best obtained by electro-deposition. The diaphragm should be as thin as possible at the center (having regard to continuity), increasing in thickness toward the margin to about seven or eight times its thickness, and thus present a somewhat concave face toward the mouth of the receiver. The electro-magnets are arranged with south polarity opposite the center or thin part of the disk, and north polarity at the margin or thicker part of the disk. —*Eng. Mechanic.*

AUSTRALIAN TIMBERS.

NOT long since a question was seriously raised regarding the alleged scarcity of tanning materials; like the subject of paper materials, the probability of any deficiency in the supply cannot be looked upon in any other than an important light. It would seem not that the natural resources of the world are absolutely failing, but that man is not sufficiently alive to his own interests to discover or develop any new industry, notwithstanding that new discoveries in science are rather the rule nowadays than the exception. Physical or mechanical science, however, seems to be the most fashionable and to find the most devotees, nevertheless there are fine fields of discovery in natural science, and more particularly in that section bearing on the application of plants; and, moreover, good reasons why those discoveries should be prosecuted are well exemplified by the demands for paper materials, tanning substances, new dyes, caoutchouc or India rubber, and new medicinal products. It is Australia to which attention is naturally directed as a source of many valuable new commercial commodities. Hitherto the long journey from England and the cost of freight have been, perhaps, the only drawbacks to the more general utilization of the vast resources of this great colony. In a climate suited in every way for the cultivation, not only of our own British orchard produce, but also of many semi-tropical fruits, it is surprising that such fruits have not before this been imported in quantities to British ports. It is to be hoped, however, that the recent importation of fresh fruits from Australia to the Paris Exhibition will sufficiently prove the capability of such a scheme, and result in a thorough system of traffic in the fruit trade, and, moreover, open fresh fields for the introduction of Australian produce generally.

In a descriptive catalogue of Victorian timbers exhibited in the Industrial and Technological Museum, Melbourne, the value of Australian woods for furniture, building, and other purposes, is exemplified. Considering the very great variety of useful and ornamental woods produced in Australia and Tasmania, it is surprising that some of the best of them, such as the Huon pine (*Dacradium Franklinii*), the Tasmanian myrtle (*Fagus Cunninghamii*), the musk wood (*Aster argophylla*), the dogwood (*Bedfordia salicina*), and others, are not more used by cabinetmakers in this country. It has always been said that the expense of freight militates against bringing heavy woods from such a distance as Australia, but if too costly to be used in substance for furniture, it would seem that they might be applied as veneers, for it cannot be denied that some of those just enumerated are unique in figure and color. It is not that these splendid woods are difficult to obtain, or that there is little prospect of a continuous supply; on the contrary, many of the trees are widely distributed, and the woods are to be had in unlimited quantities. Thus, for instance, the so-called Tasmanian myrtle, or, as it is sometimes called, the evergreen beech, occurs over a tolerably wide range in Victoria, and constituting the main forest for many miles on the Mount Baw-Baw ranges. On account of the great diameter of these massive trees, very large planks are obtainable. The wood is used in the colony for cogs of wheels, by millwrights, as well as by cabinetmakers for various articles of furniture. The musk wood tree is often found up to a height of 60 feet, but seldom or never exceeding that height. It is confined to moist umbrageous forest gullies, but is very abundant in those situations. The wood is of a yellowish or brownish color, beautifully mottled, with a very pleasant fragrance. It is hard, and suitable for fancy articles of furniture, pianofortes, as well as for turnery purposes.

In the genus *Acacia*, numerous species furnish a variety of ornamental woods. The principal of these are, perhaps, the black wood or light wood (*Acacia melanoxylon*), a large tree, abundant on the rich river flats and in the valleys. The wood is close grained and heavy, and is useful for all purposes where strength and flexibility are required, being largely used by coachbuilders in every department of the trade, as well as by coopers, for railway carriages and trucks, and in the better class of agricultural implements. The color of the wood is a rich reddish brown with dark markings, in some specimens surpassing in appearance even the finer kinds of walnut. The myall wood, now well known for making pipes, is the produce of *Acacia homalophylla*. It is a small tree found in the Mallee Scrub, valued for its fine violet scented dark colored wood; besides being used for pipes it is also applied to whip handles and small articles of turnery. This species also exudes copious supplies of gum in the summer season.

The common wattle (*Acacia decurrens*) as well as the green wattle, black wattle, and feathery wattle (*A. mollissima*), and the silver wattle (*A. dealbata*), are all valuable, not only for their woods, but for their barks, which contain tannin, and some of which are regularly used by tanners in the colony. The trees grow to a moderate height, but are very abundant in some districts, and the bark can be obtained in almost any quantity. The trees are stripped in September and the two or three months following, and the bark being allowed to dry, is at once in a condition fit for market; a useful gum known as wattle gum is procured from these trees.

So much has been said of late regarding the uses and probable extended application of the products of the *Eucalypti*, that a few notes on the products contained in the Industrial Museum at Melbourne will exemplify the value of this great genus. Of all the species the blue gum (*E. globulus*) is certainly the best known, on account of its reputation, whether justly so or not is still unproved, of purifying malarious districts. Few trees, perhaps, have ever attracted so much attention as this species. Trees have been planted in almost every country where it could possibly succeed, and even in small private gardens the blue gum is very often to be found. As a timber tree it will no doubt prove valuable, on account of the colossal size to which it grows, and its extremely rapid growth, together with the great strength and durability of the timber, which in the colony is largely used for beams, joists, etc., in buildings, and for railway sleepers, piers, and bridges. Besides the uses of the wood, the resin exudes from the tree in very large quantities. Essential oil and other extracts have also been prepared from the foliage. The most colossal species is, perhaps, *Eucalyptus amygdalina*, which is known locally under various names as stringy bark, messmate, peppermint, etc. It is said to be not uncommonly found up to a height of 420 feet, and sometimes to attain a still greater height. The wood is hard and close-grained, well adapted for house-building, planking of ships, shingles, rails, and other purposes. This species contains more oil in its foliage than any of its congeners; 1,000 lbs. of fresh gathered leaves, with their small branchlets, yield by distillation 500 ounces of oil. It is rubefacient, disinfectant, and employed externally in rheumatic affections, and in perfumery, scenting soaps, etc. The spotted gum of Victoria (*Eucalyptus goniocalyx*), is a species often found of a very large size, but mostly of moderate dimensions. The wood is hard, straight, and even-grained, and is employed in the colony chiefly for joists, beams, rafters, and heavy framing work, as well as by coopers for staves. The bark is described as being usually deciduous, but sometimes persistent. The species produces resin in very large quantities, and from 100 lbs. of fresh leaves 16 ozs. of essential oil have been obtained. For illuminating purposes, this oil is admirably adapted; it produces a brilliant white flame, superior in intensity and color to that from the best American kerosene, and its use in kerosene lamps does not cause any smoke or smell, and is free from danger. The other most useful species valued for their timber are—*Eucalyptus rostrata*, the red gum tree, a tall growing tree, very abundant along the river flats and open valleys, the wood of which is of a brownish red color, and is used alike for furniture, carpentry, agricultural implements, and ship and house building; *E. leucoxylon*, the iron bark tree, often growing to a great height, and producing, perhaps, the strongest timber of the whole of the eucalypts; and *E. obliqua*, the Victorian stringy bark tree, a gigantic tree, not unfrequently attaining a height of from 300 ft. to 400 ft., with a very thick, rugged, and fibrous bark, hence its local name.